Final
Area U Mercury Biomonitoring Report

2014

Federal Aviation Administration
William J. Hughes Technical Center

Prepared for:

FAA William J. Hughes Technical Center
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EXECUTIVE SUMMARY

The Area U Biomonitoring Study involves annually monitoring mercury and/or methylmercury levels within specific Area U biota over a ten-year period, with initial work commencing in 2005. Area U biota monitored during the study include zooplankton, fish (forage fish and average-sized omnivorous and piscivorous species), and birds (tree swallow eggs) within the Upper and Lower Atlantic City Reservoirs (Upper Reservoir and the Lower Reservoir) while aquatic macroinvertebrates (Isopoda and Odonata), forage fish, and bats (northern long-eared bat fur) have been monitored within the South Branch of Absecon Creek (SBAC). In addition, large piscivorous fish have been sampled periodically from the two reservoirs during the biomonitoring period. This report addresses biota monitored in the Upper and Lower Reservoirs in 2014 as well as northern long-eared bats within Area U.

A significantly increasing trend in methylmercury or mercury concentrations is present within zooplankton, forage fish, average-sized bluegills, chain pickerel, largemouth bass and tree swallow eggs sampled from both the Upper Reservoir and Lower Reservoir during 2004 through 2014. A significantly increasing trend was also noted in average-sized yellow perch collected over this same time period within the Lower Reservoir. The significantly increasing trends likely can be attributed to changing water levels within the Upper Reservoir that promote the production of methylmercury within the Upper Reservoir sediments into the overlying surface water. After a prolonged period of drawdown within the Upper Reservoir (from Fall 2004 through 2010), the high water levels initially present in Fall 2011 within the Upper Reservoir likely resulted in high levels of methylmercury being produced within the re-inundated sediments where it was subsequently released to the overlying surface water. The increased methylmercury levels within the Upper Reservoir and Lower Reservoir (receives discharge from the Upper Reservoir) then bioaccumulated to high concentrations within zooplankton and macroinvertebrates with subsequent biomagnification to forage fish, tree swallows and larger fish. Levels of mercury and methylmercury within Upper Reservoir and Lower Reservoir biota have remained elevated since 2011.

The concentrations of methylmercury observed in zooplankton collected from the Lower Reservoir are correlated with the amount of precipitation received during the previous nine months. This is not surprising as the mercury source(s) to the Lower Reservoir are believed to be associated with the Upper Reservoir and/or seeps within its drainage basin. The greater the amount of precipitation, the greater the discharge of surface water from the Upper Reservoir to the Lower Reservoir. A negative correlation was also noted with the relative biomass of Calanoida copepods and methylmercury concentrations in Lower Reservoir zooplankton. No strong correlations were noted between Upper Reservoir zooplankton methylmercury levels and the amount of precipitation.

The varying concentrations of mercury observed in forage fish collected from the Upper Reservoir are correlated with the concentrations of methylmercury detected within zooplankton during the year prior to sampling and also (to a lesser degree) the methylmercury concentration detected in zooplankton at the same time as the forage fish sampling. Forage fish would be expected to consume zooplankton and bioconcentrate mercury received through their diet. No strong correlations were noted in forage fish collected from the Lower Reservoir with zooplankton methylmercury concentrations or the amount of precipitation received.

The concentrations of mercury observed in piscivorous fish (i.e., largemouth bass and chain pickerel) collected from the Upper Reservoir are correlated with the amount of mercury present within forage fish. This is not surprising as these piscivorous fish would prey on the forage fish for a substantial portion of their diet. Although bluegill mercury concentrations were also correlated (but less strongly) with forage fish mercury levels, this correlation is likely to reflect similar modes of exposure (diets containing varying proportions of aquatic invertebrates). No strong correlations were noted between Lower Reservoir fish mercury levels and the factors evaluated although the highest correlations were noted between piscivorous fish and forage fish mercury levels.

Bluegills and forage fish within the Upper Reservoir and yellow perch within the Lower Reservoir may be at risk as mercury concentrations within these species exceeds a 24 percent injury factor. Bluegills and forage fish inhabiting the Lower Reservoir would not appear to be adversely affected by mercury due to their substantially lower tissue concentrations (below the 24 percent injury factor). Levels of mercury detected within largemouth bass and chain pickerel sampled from the Upper Reservoir nearly equal or exceed a 50 percent injury factor in six of the previous seven years. Although levels of mercury in these species collected from the Lower Reservoir are lower, chain pickerel mercury concentrations equal or exceed the 50 percent injury factor in three of the four most recent years of sampling. These results suggest that impacts to upper trophic level fish may be occurring at both reservoirs but particularly within the Upper Reservoir. The numbers of largemouth bass noted during the 2014 sampling event within both the Upper and Lower Reservoirs declined substantially from numbers observed in the preceding years. It is unknown if this decrease may be associated with consistently elevated mercury concentrations or other environmental factors.

Risks to aerial insectivores (tree swallow and northern long-eared bat) that forage on insects within Area U are possible based on mercury concentrations detected in tree swallow egg and bat fur. Approximately 50 and 33 percent of the sampled tree swallow eggs from the Upper and Lower Reservoirs, respectively, exceed an upper threshold associated with reproductive impairment in avian species including the tree swallow. Over 95 percent of tree swallow eggs collected within the past three sampling events at the Upper Reservoir (2012 through 2014) exceed the upper threshold value indicating risks to this species have increased substantially over previous years. Risks to northern long-eared bats are also possible as approximately 50 percent of the bat fur samples over the biomonitoring period exceed a threshold concentration associated with neurological effects in bats. It should also be noted that almost all of the bats that were recaptured during the biomonitoring study had higher mercury concentrations present in their fur than the levels noted during their initial capture. Overall, northern long-eared bats foraging within Area U are exposed to mercury and may potentially be adversely affected by mercury as fur mercury concentrations are elevated above a threshold level associated with neurological effects, particularly as they get older and are repeatedly exposed to mercury.

The mean forage fish concentrations of mercury at the Upper Reservoir exceed the kingfisher Lowest Observable Adverse Effect Level (LOAEL) toxicity reference values (TRV) associated with reproductive impairment for all 12 years that forage fish were collected. At the Lower Reservoir, reproductive risk to kingfishers from the ingestion of forage fish generally increased from 2005 until 2011, when the mean forage fish mercury concentration was slightly below the kingfisher LOAEL TRV. However, risks to the belted kingfisher in 2012 through 2014 from foraging on fish at the Lower Reservoir increased to levels above the LOAEL TRV. When the risk associated with foraging on small fish at both reservoirs combined is evaluated, the results suggest even further that reproductive impacts to kingfishers potentially are present.

Risks to osprey associated with ingestion of average-size fish at the Upper and Lower Reservoirs indicate a potential reproductive risk from foraging on predator fish (chain pickerel and largemouth bass) within the Upper and Lower Reservoirs from 2011 through 2014. Prior to 2011, the concentrations of mercury within predator fish as well as omnivorous species such as bluegill and yellow perch were generally above the osprey fish tissue NOAEL TRV but below the LOAEL TRV. Similar to risks noted for the kingfisher, risks associated with ospreys are increased substantially when foraging is assumed to occur at both reservoirs and potential impacts are expected to be in the form of a reduction in their reproduction.

Mean mercury concentrations in bluegills, chain pickerel and largemouth bass at the Upper Reservoir and chain pickerel, largemouth bass and yellow perch sampled at the Lower Reservoir exceed the mink LOAEL fish tissue TRV based on actual mink mortality. Fish tissue concentrations of mercury detected at both the Upper and Lower Reservoir strongly suggest that mercury-related impacts to mink may result from consuming average-sized fish from these reservoirs. As significantly increasing trends in mercury concentrations have been observed in forage fish from the Upper Reservoir and within average-sized fish within both reservoirs, the risks to piscivorous species including the belted kingfisher, osprey and mink have also steadily increased over the duration of the biomonitoring period.

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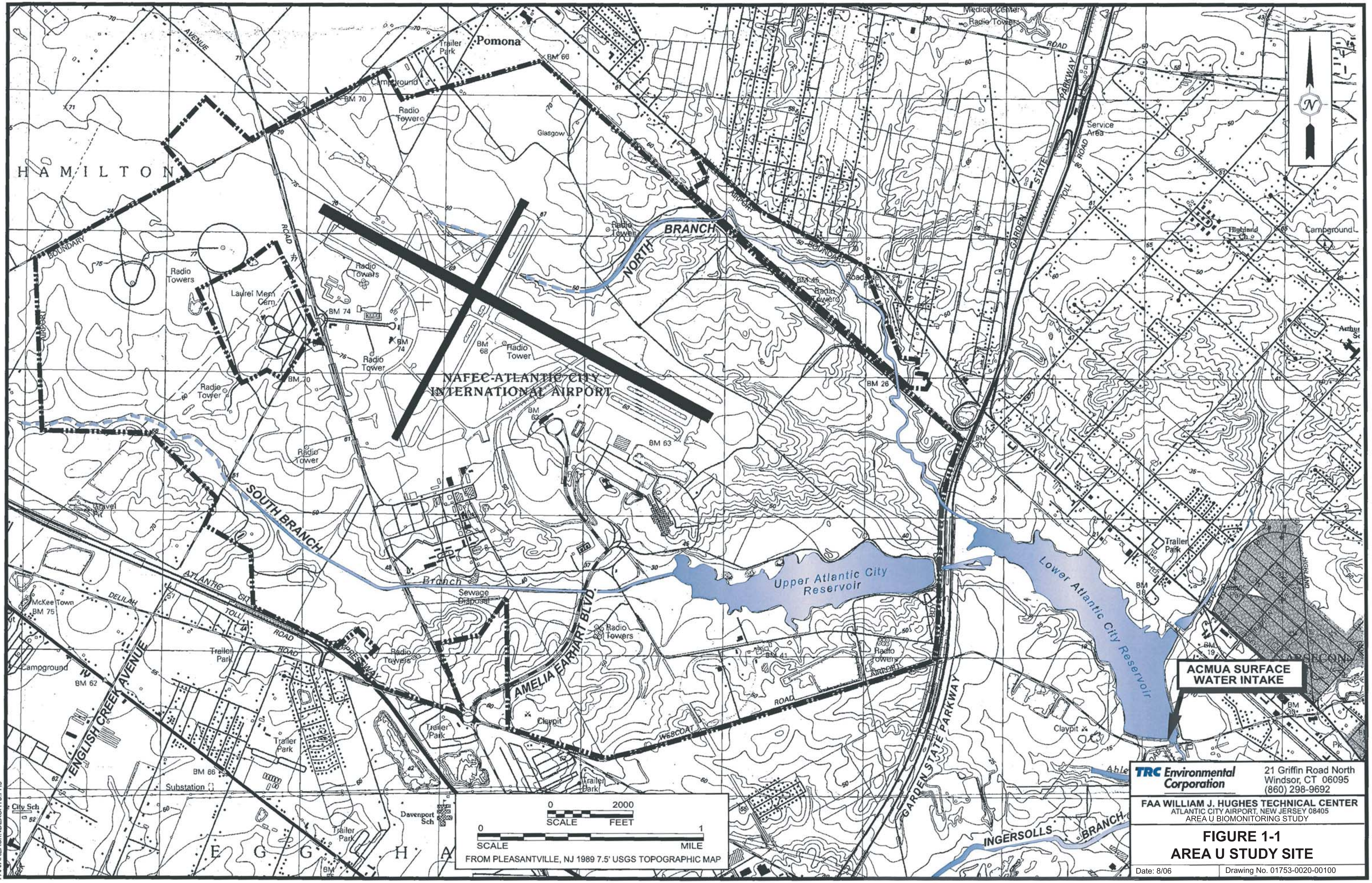
1.0 INTRODUCTION

This report presents the results from mercury biomonitoring during 2005 through 2014 within Superfund Area U at the Federal Aviation Administration William J. Hughes Technical Center (FAA Technical Center) at Atlantic City International Airport, Atlantic County, New Jersey. Figure 1-1 depicts the approximate limits of the Area U study area. The Area U Biomonitoring Study involves annually monitoring mercury and/or methylmercury levels within specific Area U biota over a nine-year period with initial work commencing in 2005. In addition, samples of biota collected during the 2002 Ecological Risk Assessment (TRC, 2004) and/or 2004 Supplemental Remedial Investigation/Ecological Risk Assessment (TRC, 2010) were also considered in this report.

The biomonitoring efforts are essential in ascertaining the annual distribution and variability of mercury within the aquatic ecosystems in Area U as well as potential factors responsible for any observed differences in the yearly results. In addition, the biomonitoring data can be used to evaluate the effectiveness of any future remediation efforts. Ultimately, this action is intended to be long-term and is likely to be part of the remedial action plan for Area U.

The previously submitted Biomonitoring Work Plan (TRC, 2006) was developed to facilitate annual comparisons between mercury and/or methylmercury levels within various biota inhabiting Area U. In this manner, temporal and spatial variability in mercury concentrations within Area U biota can be determined. Area U biota monitored includes zooplankton, aquatic macroinvertebrates (Isopoda and Odonata), fish (forage fish and average-sized omnivorous and carnivorous species), birds (tree swallow eggs) and bats (northern long-eared bat fur). Although adverse effects of mercury on ecological receptors are most likely to be exhibited in mid- to upper trophic level species inhabiting Area U, lower trophic levels are more likely to reflect a quicker response in decreasing mercury contamination due to remediation efforts. Therefore, various trophic level receptors were proposed to be monitored. The primary objectives of the long-term biomonitoring studies are as follows:

- Characterize temporal and spatial variability in mercury/methylmercury tissue concentrations prior to implementation of remediation activities;
- Monitor effectiveness of potential future remedial activities in reducing mercury/ methylmercury concentrations in biota tissue (i.e., trend analysis); and
- Evaluate risk to upper trophic level species from detected mercury/methylmercury concentrations within upper and lower trophic level biota.



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2.0 BIOMONITORING STUDY METHODS

The following sections present a summary of the sampling design and methods for each group of taxa where biomonitoring was conducted. A detailed discussion of taxa-specific study objectives and experimental designs, including proposed analyses is provided in the Area U Biomonitoring Work Plan (TRC, 2006).

2.1 Zooplankton Biomonitoring

The Area U Supplemental Remedial Investigation (RI)/Ecological Risk Assessment (ERA) (TRC, 2010) concluded that zooplankton represent an important pathway in the transport of methylmercury from the very low surface water concentrations of methylmercury detected at the Upper Atlantic City Reservoir (Upper Reservoir) and Lower Atlantic City Reservoir (Lower Reservoir) to the fish inhabiting these waterbodies. In general, zooplankton represent lower trophic level organisms that are relatively short-lived and bioaccumulate methylmercury directly from the surface water. Therefore, biomonitoring of zooplankton would reflect short-term changes in methylmercury concentrations within the surface waters of the reservoirs that may increase or decrease depending on particular operational or remedial activities that are occurring.

Zooplankton samples were collected in the fall of 2005 through 2014 via horizontal tows using a Wisconsin-style plankton net with 153µm nylon mesh. One to three samples were each collected from the Upper and Lower Reservoirs depending on water levels present within the reservoirs at the time of sample collection. In 2005 and 2006, two samples were collected within both the Upper and Lower Reservoirs at sampling locations that correspond to the previous sampling locations for the Supplemental RI/ERA (TRC, 2010). In 2007 only one sample was collected from the Lower Reservoir while in 2008 only one sample was collected from the Upper Reservoir. In 2009, three horizontal tow samples were collected from each reservoir while three vertical samples were each collected from the Upper and Lower Reservoirs in order to determine the relative composition of the zooplankton communities present. Two horizontal tow samples and one vertical sample were collected from the Upper Reservoir while three horizontal and three vertical samples were collected from the Lower Reservoir in 2010. In 2011 through 2014, three horizontal tow samples and two to three vertical samples were collected from each reservoir. The approximate sampling locations are depicted on Figure 2-1. Samples were shipped via overnight delivery to Brooks Rand Laboratory where each sample was analyzed for methylmercury and percent solids (in order to present results consistently in dry weight). Samples collected for zooplankton community analyses were shipped to PhycoTech, Inc. for taxonomic identification (genus level) and biovolume determination.

Legend

- Lower Reservoir Sample
- Upper Reservoir Sample
- SBAC Main Channel
- 1957 SBAC Stream Channel
- FAA Property Line

N
W E
S

0 350 700 1,400 Feet

Note: The orthophoto shown in this map was taken on March 19, 2001

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AREA U - BIOMONITORING STUDY

ZOOPLANKTON SAMPLING LOCATIONS

Figure 2-1	Date: 8/06	Project No: 01298-0020-00100

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2.2 Aquatic Macroinvertebrate Biomonitoring

The Supplemental RI/ERA (TRC, 2010) rationale for identifying a mercury source area west of Tilton Road was based primarily on initial results of mercury and/or methylmercury concentrations within aquatic macroinvertebrate (Isopoda and Odonata) samples. These aquatic macroinvertebrates have demonstrated their suitability in assimilating mercury and are also very useful in identifying mercury input zones to Area U both spatially and temporally. For these reasons, both Isopoda (isopods) and Odonata (dragonflies) were selected as appropriate biomonitoring organisms within the South Branch of Absecon Creek (SBAC). In this regard, they will serve a similar function within the SBAC that zooplankton provide in biomonitoring lower trophic levels within the Upper and Lower Reservoirs.

2.2.1 Isopoda

Isopods are crustaceans that represent relatively short-lived (i.e., approximately one year or less) and fairly sedentary organisms that are typically found along the stream bottom (in or under mud, vegetation and/or detritus). Breeding may occur throughout the year. Isopods are scavengers feeding on both dead animal and plant matter. Due to their short lifespan, isopods are good indicators that would rapidly reflect reductions in mercury contamination within the SBAC as the result of potential future remediation efforts.

Sampling of isopods was consistent with the methods used in the Supplemental RI/ERA (TRC, 2010). Each sampling location consisted of rectangular-shaped plots five meters (m) in length that were centered on the SBAC main channel. Sampling generally consisted of only a single isopod species (*Asellus* sp.). If sufficient mass of isopods could not be obtained at a particular sampling location, then functionally similar mayfly (Ephemeroptera) taxa were collected. The collection of mayfly larvae to supplement isopod collection was necessitated at only one sampling location (SB-07). The cause of the noted decrease in isopod abundance at this sampling location may be related to habitat differences or associated with an impaired aquatic invertebrate community due to significant inputs of mercury within upstream areas of the SBAC.

Isopods were collected via aquatic D-nets at eight locations within the SBAC during the late summer of 2005 through 2013. Samples were not collected in 2014 and are not proposed until 2016 as recommended in the 2013 Area U Mercury Biomonitoring Report. Collection areas corresponded to a subset of the previous aquatic invertebrate sampling locations within the contaminated portion of the SBAC as well as an upstream reference area(s). The sampling locations are presented in Figure 2-2. Sampling proceeded from downstream locations to upstream locations. Isopods were rinsed with distilled water after collection to remove adhered

Legend

- Isopoda Sample (Stream Gage)
- SBAC Main Channel
- 1957 SBAC Stream Channel
- FAA Property Line

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0 350 700 1,400
Feet

Note: Orthoimagery, New Jersey Office of Geographic Information Systems, 2007

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ISOPODA SAMPLING LOCATIONS
SOUTH BRANCH ABSECON CREEK

Figure 2-2	Date: 12/13	Project No: 162662-0100-0562

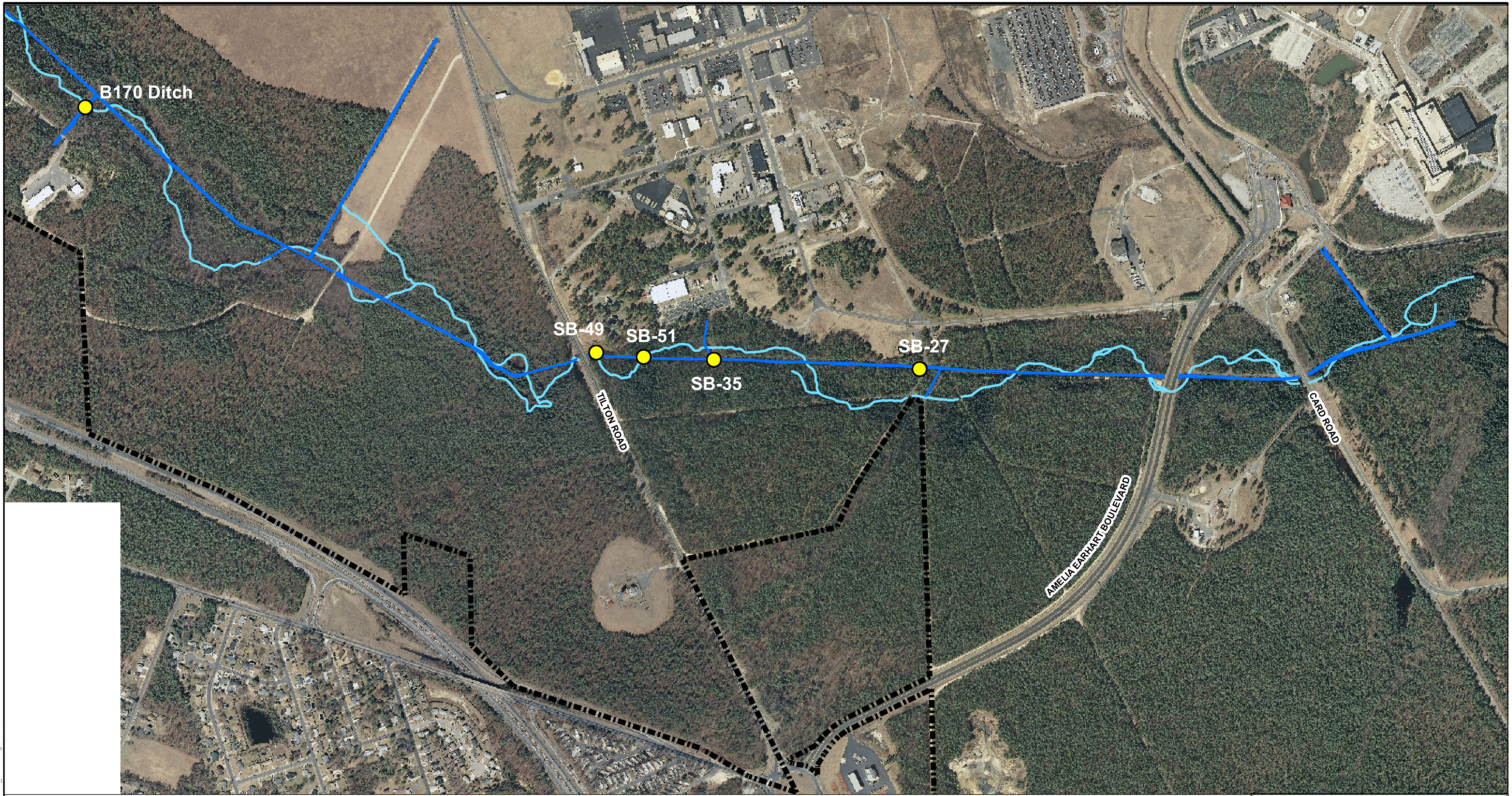
R:\Projects\GIS_2004\02198_FAA\2013_DEC\AbeseconCreek_Isopoda_2013_12_19.mxd sediment and placed in laboratory-supplied clean glass jars. A sample mass of approximately one gram is required for each sample in order to analyze for methylmercury.

2.2.2 Odonata

Odonata larvae differ from isopods in that they represent predaceous aquatic insects that inhabit aquatic habitats within Area U for a much longer period. The larvae stage of some odonates may be four to five years in length. Due to their higher trophic status as well as their longer exposure period, odonate larvae typically have comparatively higher mercury concentrations than isopods. Previous Odonata sampling and mercury tissue analysis in 2005 was restricted to SBAC main channel locations situated west of Tilton Road (TRC, 2010). Although elevated mercury concentrations are anticipated within Odonata inhabiting that portion of the SBAC downstream of Tilton Road, samples were needed in this section of the SBAC to ascertain baseline mercury levels within Odonata. It was unknown whether older Odonata larvae (i.e., four years old) have higher mercury body burdens than younger larvae (i.e., two or three years old). Therefore, Odonata samples in 2006 included both young and older larvae (based on relative total size) from co-located sampling locations to determine whether future sampling (i.e., 2007 and later) needs to take into account the approximate age of collected larvae. Based on the 2006 sampling results, it was determined that there were no significant differences in mercury concentrations between older and younger odonate larvae. Therefore, although the relative size of each odonate larva was noted during the subsequent sampling, the actual age of Odonata larvae was not determined.

Pangaegaster maculata larvae were initially collected by Dr. Frank Carle (Rutgers University) during field activities associated with the Supplemental RI/ERA (TRC, 2010). *Pangaegaster maculata* represents a large, predaceous, dragonfly larva that burrows into sediment and is relatively easy to find throughout the SBAC. *Pangaegaster maculata* may be present as larvae for a period of up to three to four years. Given their long larval stage and predacaceous feeding habit, this species represents an aquatic invertebrate particularly useful in evaluating mercury bioaccumulation.

Odonata larvae samples were collected in 2006 through 2012 using a small nylon net or seine. No odonate larvae were collected in 2013 or 2014. Larvae (consisting of medium-size to large-size *Pangaegaster maculata*) were collected from various locations in the SBAC in order to determine mercury concentrations within the SBAC on a spatial and temporal basis. Sampling locations are depicted on Figure 2-3. The odonata larvae were rinsed with water after collection to remove adhered sediment, weighed and placed into separate clean glass sample jars. Samples were stored in a freezer at $\leq$-20°C until shipped by overnight delivery to the analytical laboratory for total mercury analysis (EPA Method 7474).



Legend

- SBAC Main Channel
- 1957 SBAC Stream Channel
- FAA Property Line
- ODONATA SAMPLE

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0 350 700 1,400
Feet

Note: The orthophoto shown in this map was taken on March 19, 2001

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ODONATA SAMPLING LOCATIONS
SOUTH BRANCH ABSECON CREEK

Figure 2-3	Date: 8/06	Project No: 01298-0020-00100

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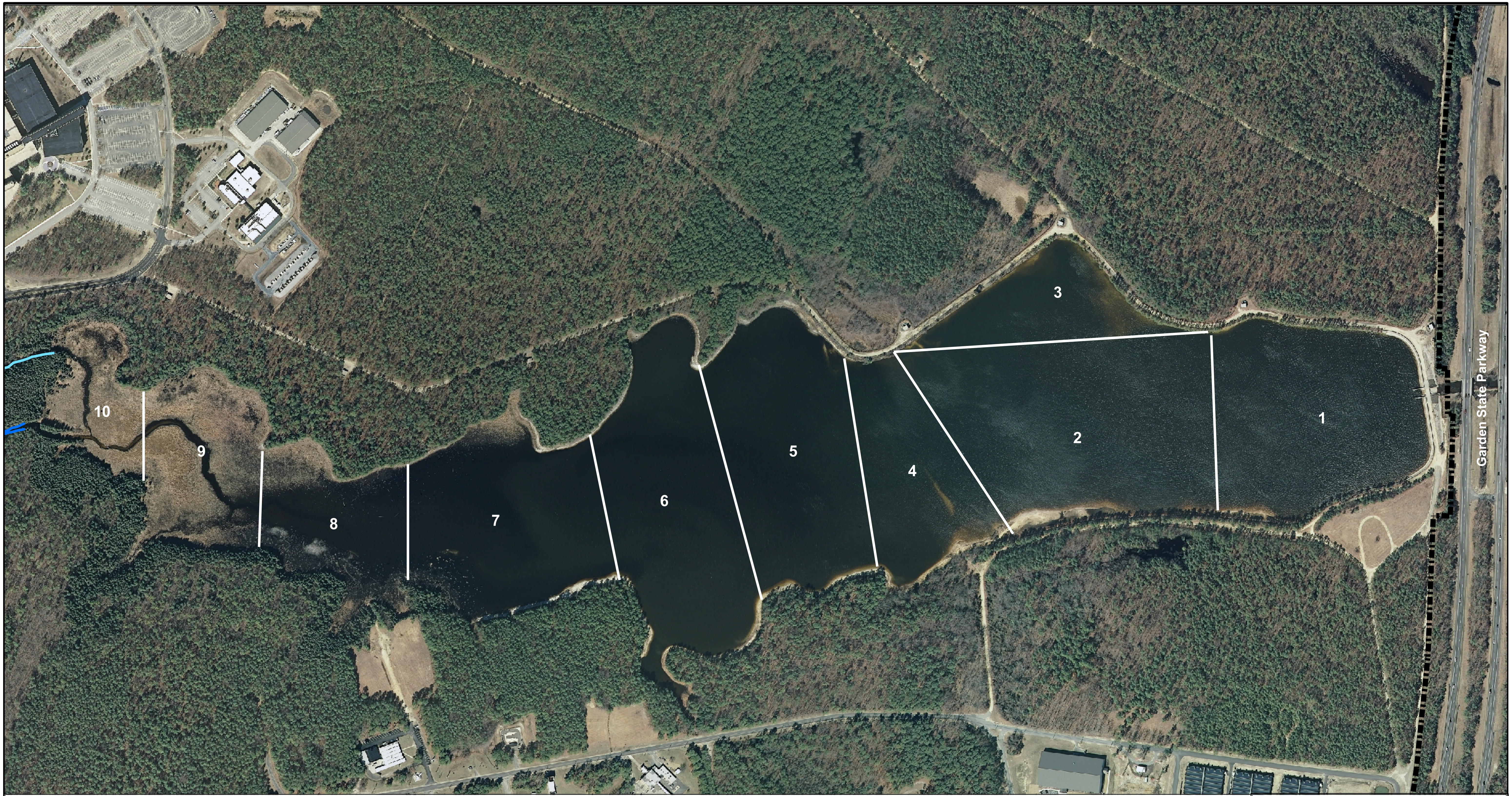
2.3 Fish Community Biomonitoring

2.3.1 Forage Fish

The Supplemental RI/ERA (TRC, 2010) determined that the likely mercury transport pathway within the Upper and Lower Reservoirs are from surface water to zooplankton to planktivorous fish to predator fish. Small forage fish (e.g., sunfish, killifish) represent an important middle component of this mercury transport pathway. Forage fish feed upon zooplankton and, in turn, are predated upon by larger fish as well as various avian piscivores (e.g., belted kingfisher, herons). Forage fish are generally shorter lived than larger fish and represent mid-trophic level species that would be expected to respond more quickly to changing methylmercury concentrations within the surface waters of the aquatic environments they inhabit.

Forage fish were collected from the Upper Reservoir (six samples located in different locations) and Lower Reservoir (five samples located in different locations) in early fall in 2005 through 2012. In addition, forage fish samples from both reservoirs were collected in 2002 and 2004 and included in the data set. Samples were distributed throughout each reservoir with no more than one sample collected within each of the 10 sampling polygons established for each reservoir (Figures 2-4 and 2-5). Sampling locations at the reservoirs were determined in the field at the time of the sampling and were based upon existing field conditions (i.e., water levels). Fish were collected primarily by seining. A minimum of three forage fish were used as a composite sample at each sampling location. Fish were identified to species and sent by overnight delivery to the analytical laboratory. Each sample was analyzed for total mercury by EPA Method 7474.

In 2009 through 2012, forage fish were also collected from the SBAC and from the tidal portion of Absecon Creek below the Lower Reservoir spillway. Forage fish were previously sampled from 10 locations within the SBAC in 2002 but have not been resampled from the SBAC until 2009. Collection of forage fish within both the SBAC and the tidal portion of Absecon Creek provides useful information concerning the variability of mercury concentrations within these aquatic habitats as well as document conditions post-remedial activities. Four samples were collected from the SBAC and tidal portion of Absecon Creek in 2009 through 2012 with D-nets and by seining. In 2013, a total of eight forage fish samples were collected from the SBAC including former meanders of the SBAC while sampling of forage fish within Absecon Creek was discontinued (as recommended in the 2012 Area U Mercury Biomonitoring Report). Samples from the SBAC consisted of one to two eastern mudminnows (*Umbra pygmaea*) while composite samples of three killifish (mummichog or striped) comprised each of the tidal Absecon Creek samples. Sampling of forage fish within the SBAC was not conducted in 2014 and will resume in 2016 as recommended in the 2013 Area U Mercury Biomonitoring Report.



Legend

- SBAC Main Channel
- 1957 SBAC Stream Channel
- FAA Property Line

N
W E
S

0 350 700
Feet

Note: The orthophoto shown in this map was taken on March 19, 2001

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FISH SAMPLING AREAS
UPPER RESERVOIR

Figure 2-4	Date: 8/06	Project No: 01298-0020-00100

Legend

FAA Property Line

N E S W

0 350 700

Feet

Note: The orthophoto shown in this map was taken on March 19, 2001

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FISH SAMPLING AREAS
LOWER RESERVOIR

Figure 2-5	Date: 8/06	Project No: 01298-0020-00100

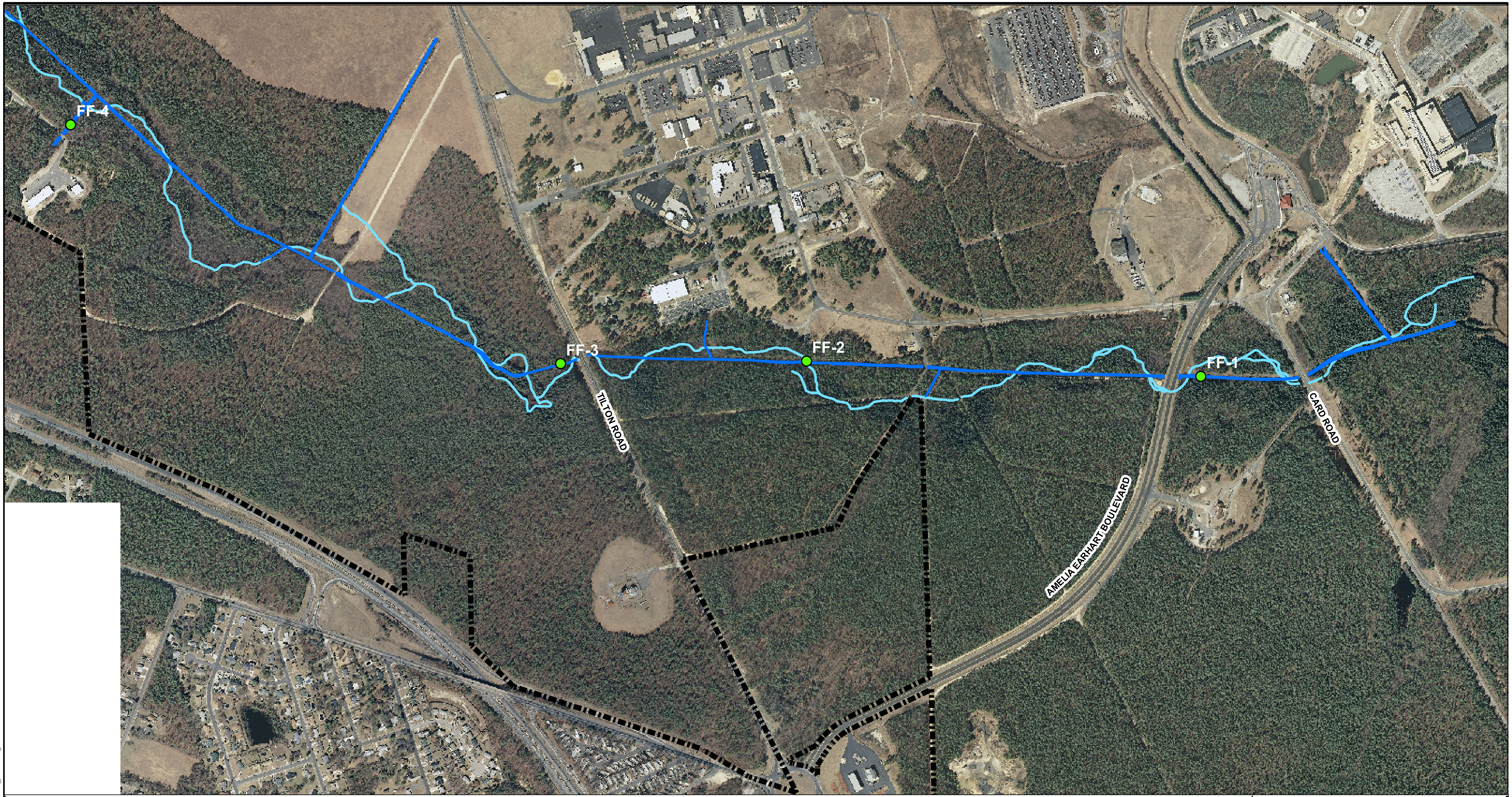
Sampling locations within the SBAC and Absecon Creek are depicted in Figures 2-6 and 2-7, respectively. Fish were identified to species and sent by overnight delivery to the analytical laboratory. Each sample was analyzed for total mercury (EPA Method 7474).

2.3.2 Average-Sized Fish

The Supplemental RI/ERA (TRC, 2010) determined mercury concentrations in average-sized fish present within the Upper and Lower Reservoirs. Average-sized fish inhabiting the two reservoirs represent an important component of the food chain exposure pathway. Risks to piscivorous species (i.e., osprey, mink) were also assessed in the Supplemental RI/ERA (TRC, 2010) and found to be present for both avian and mammalian piscivores although the risk magnitude ranged from low (osprey) to high (mink). Biomonitoring mercury concentrations within average-sized fish will evaluate existing variability in mercury concentrations as well as assist in determining the effectiveness of remediation activities, particularly in regards to evaluating risk to the upper trophic level piscivorous species that forage at the Upper and Lower Reservoirs.

Average-sized fish representing the most common fish species present were collected from the Upper and Lower Reservoirs in early fall of 2004 through 2014. Species collected were bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), chain pickerel (*Esox niger*), and largemouth bass (*Micropterus salmoides*). Every effort was made to distribute samples throughout each reservoir with no more than one sample collected within each of the 10 sampling polygons established for each reservoir (see Figures 2-4 and 2-5). A total of 18 average-sized fish were collected from the Upper Reservoir (6 samples each of bluegill, largemouth bass and chain pickerel) in 2004, 2005, 2007, 2009 through 2014 while a total of 16 fish were collected from this waterbody in 2006 and 2008 (only 4 chain pickerel samples were collected during each of these years). A total of 16 average-sized fish were collected from the Lower Reservoir each year in 2004 through 2009 (4 samples each of bluegill, largemouth bass, chain pickerel and yellow perch) while 20 fish (5 samples of each species) were collected in 2010, 2011 and 2013. In 2012 and 2014, 3 or 4 largemouth bass and 5 bluegill, chain pickerel and yellow perch were collected from the Lower Reservoir for a total of 18 - 19 fish. Fish were collected using hoop nets and/or angling. Samples were sent by overnight delivery to the analytical laboratory for tissue (whole-body) analysis. Each sample was analyzed for total mercury by EPA Method 7474.

All fish captured during each year of the biomonitoring study were measured (to nearest millimeter) and weighed (generally within nearest 5 gram increment) regardless of whether the fish was retained for mercury analysis. The length-weight relationships of fish from the two



Legend
- Forage_Fish
- SBAC Main Channel
- 1957 SBAC Stream Channel
- FAA Property Line

N W E S

0 350 700 1,400
Feet

Note: The orthophoto shown in this map was taken on March 19, 2001

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FORAGE FISH SAMPLING LOCATIONS
SOUTH BRANCH ABSECON CREEK

Figure 2-6	Date: 8/06	Project No: 01298-0020-00100

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Legend

- Fish Sampling Location
- SBAC Main Channel
- 1957 SBAC Stream Channel
- FAA Property Line

0 350 700 1,400 Feet

N W E S

Note: The orthophoto shown in this map was taken on March 19, 2001

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FISH SAMPLING LOCATIONS
TIDAL PORTION OF ABSECON CREEK

Figure 2-7	Date: 8/06	Project No: 01298-0020-00100

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reservoirs were then assessed via the Fulton Condition Factor (K). This condition factor was calculated for each individual fish. It is calculated by the following equation:

$$K = (W / L^3) * 100{,}000$$

where W represents weight in grams and L is length in mm. Although best suited for rotund fish (e.g., sunfish) it is also useful for assessing the condition of other fishes, particularly when comparing populations annually. The individual fish were then grouped into several size classes for each species.

2.3.3 Large Fish

Large fish would be representative of maximum concentrations within fish inhabiting the reservoirs as mercury concentrations within fish are directly correlated with the total fish length (Horowitz, et al., 1999). The maximum concentrations within these large fish would represent upper concentrations that may affect the fish themselves (e.g., lower reproduction or survival rates) as well as piscivorous species that may prey on large fish.

Large individuals of chain pickerel and largemouth bass were collected from the Upper and Lower Reservoirs in 2002, 2009, and 2013. In 2002, a total of 12 large fish (2 chain pickerel and 10 largemouth bass) and 10 large fish (5 each of chain pickerel and largemouth bass) were collected from the Upper and Lower Reservoirs, respectively. In addition, composite samples of three large chain pickerel or largemouth bass were also collected and sampled in 2002. The results of these composite samples (6 from the Upper Reservoir and 5 from the Lower Reservoir) were also included in the 2002 large fish samples. In 2009, eight large fish (three chain pickerel and five largemouth bass) from the Upper Reservoir and six large fish (two chain pickerel and four largemouth bass) were collected from the Lower Reservoir. In 2013, five large chain pickerel and five large largemouth bass were collected from each reservoir.

Fish were collected with hoop nets (2002 only) and/or angling. Samples were sent by overnight delivery to the analytical laboratory for tissue (whole-body) analysis. Each sample was analyzed for total mercury by EPA Method 7474.

2.4 Bat Community Biomonitoring

Northern long-eared bats (*Myotis septentrionalis*) and big brown bats (*Eptesicus fuscus*) were previously collected from portions of Area U (SBAC, NBAC, Lower Reservoir) with specific tissues (i.e., brain, kidney, liver, testes, hair and guano) analyzed for mercury concentrations (TRC, 2004; TRC, 2010). In addition, tissues of these bat species were also collected from reference areas (Wharton State Forest) and the mercury concentrations compared to levels detected at Area U. Although big brown bat tissues originating from Area U and the reference area did not contain significant differences, levels of mercury were statistically higher in the tissues of northern long-eared bats collected from Area U.

One of ten northern long-eared bats collected at Area U contained elevated concentrations of mercury within brain, kidney and liver tissues above levels reported to result in adverse effects to other mammalian species. In addition, the concentrations of mercury within the hair of northern long-eared bats were determined to be significantly correlated with mercury levels within kidney and liver tissues. Therefore, biomonitoring of bats within Area U during 2006 through 2012 involved the collection of northern long-eared bat hair samples for mercury analysis. Bats were not monitored in 2013 but sampling was again conducted in 2014.

Bats were monitored via mist nets during the summers of 2006 through 2012 within Area U over the course of four to eight site visits. The bat biomonitoring was conducted from June through late July/early August. This period of time is expected to include the important periods of bat natural history in their summer habitat (i.e. maternity period in June and foraging/dispersal of juveniles in July). Each site visit generally consisted of three nights in order to account for variability in weather. Nylon mist nets of several sizes and configurations were set across or adjacent to the SBAC and NBAC, and across forest canopy-covered dirt roads near the two creeks. The locations of mist net capture locations are depicted on Figure 2-8.

Nets were checked every 5-15 minutes and captured bats placed in cloth bags until they could be examined later that evening. All captured bats were identified to species, sexed, measured (forearm length, weight, ear length, etc.), and aged (classified as adult or juvenile based on development of bony finger joints). All bats were uniquely marked using numbered, aluminum, butt-lipped bands placed loosely on the right (male) or left (female) forearm. Bats were released the night of capture. Atmospheric conditions (e.g., temperature, relative humidity) were measured and recorded at the start and end of mist netting each night.

Samples of fur were collected from northern long-eared bats captured using mist nets. Collection of bat fur samples within Area U was conducted by Dr. Lance Risley of William Paterson University. A total of 21 fur samples were collected from northern long-eared bats within Area U in 2006 while 36 fur samples were analyzed in 2007. In 2008, 24 fur samples were analyzed while 14 fur samples were analyzed in 2009. A total of 39 and 29 bat hair samples were collected from northern long-eared bats within Area U in 2010 and 2011, respectively. In 2012, a total of 24 northern long-eared bat hair samples were collected. No samples were collected in 2013 while only 2 northern long-eared bat hair samples were collected in 2014. Samples were stored at -20° C until sent by overnight delivery to the analytical laboratory where the samples were analyzed for total mercury by EPA Method 7474.

Legend

- Bat Sampling Location
- SBAC Main Channel
- 1957 SBAC Stream Channel
- FAA Property Line

N W E S

0 350 700 1,400 2,100 2,800 Feet

Note: The orthophoto shown in this map was taken on March 19, 2001

TRC Environmental Corporation
21 Griffin Road North
Windsor, CT 06095
(860) 298-9692

FAA WILLIAM J. HUGHES TECHNICAL CENTER
ATLANTIC CITY AIRPORT, NEW JERSEY 08405
AREA U - LONG-TERM BIOMONITORING STUDY

Bat Sampling Locations

Figure 2-8	Date:1/13	Project No: 162662

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2.5 Avian (Aquatic Insectivore) Community Biomonitoring

As a component of the Supplemental RI/ERA (TRC, 2010), concentrations of mercury were evaluated within eggs of tree swallows (*Tachycineta bicolor*) collected from the Upper and Lower Reservoirs. The tree swallow represents a mid-trophic level insectivorous species. Mercury concentrations in avian eggs reflect mercury exposure to the female adult within a relatively short period of time prior to the initiation of egg-laying. Therefore, biomonitoring of tree swallow eggs for mercury levels would reflect changes in mercury exposure at the two reservoirs over time. These changes would primarily reflect changes within aquatic invertebrate mercury concentrations due to either short-term changes in methylmercury concentrations within the surface waters or sediments of the reservoirs that may increase or decrease depending on particular operational or remedial activities that are occurring or have previously occurred.

A total of 11 tree swallow nest boxes are currently present within the Upper Reservoir while 7 tree swallow nest boxes are present within the Lower Reservoir. The locations of these nest boxes are depicted in Figures 2-9 and 2-10, respectively. Tree swallow eggs were collected from a subset of the existing nest boxes in place within the Upper and Lower Reservoirs. Although only one egg was generally collected from each sampled nest box, tree swallow eggs that fail to hatch were also salvaged and analyzed. In addition, tree swallow eggs were collected from wood duck nest boxes if noted nesting in these boxes. Eggs were placed into appropriate sampling jars and shipped via overnight delivery to the analytical laboratory. The content of each egg was analyzed for total mercury (EPA Method 7474). Two to three trips per year were generally conducted to collect the eggs from both reservoirs (one trip in early May, one trip in mid-May, and one trip in early June to salvage unhatched eggs). However, due to logistical constraints associated with the egg collection permit in 2007, only one trip in late spring was conducted. Two tree swallow eggs were collected from each reservoir in 2007. No tree swallow eggs were collected in 2010 or 2011. In 2012 and 2013, four tree swallow eggs were collected each year from the Lower Reservoir while five and ten eggs were collected from the Upper Reservoir during 2012 and 2013, respectively. In 2014, 5 and 11 eggs were collected from the Lower Reservoir and Upper Reservoir, respectively.

2.6 Data Validation and Statistical Analyses

Analytical results from the laboratories were validated in accordance with New Jersey and U.S. EPA Region 2 guidelines. Sample results with undetected concentrations of mercury/ methylmercury were evaluated using the laboratory reporting limit for the sample. Data from each sampling event was evaluated to determine if mean concentrations between different years vary and if trend(s) are present within the mercury concentrations. Data were first tested for normality (Shapiro-Wilk W test) and outliers (Dixon's or Rosner's outlier tests depending on the

Legend

- 1957 SBAC Stream Channel
- Current SBAC Stream Channel & Tributaries
- FAA Property Boundary
- Tree Swallow Next Box
- Wood Duck Nest Box

N W E S

The orthophoto shown in this map was taken on March 19, 2001.

0 125 250 500 Feet

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5 Waterside Crossing
Windsor, CT 06095
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TREE SWALLOW AND WOOD DUCK NEST BOX LOCATIONS UPPER RESERVOIR

Figure 2-9	Date: 8/06	Project No: 162662.000100

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Legend

- FAA Property Boundary
- Tree Swallow Next Box
- Wood Duck Nest Box

N
W E
S

The orthophoto shown in this map was taken on March 19, 2001.

0 150 300 600 Feet

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TREE SWALLOW AND WOOD DUCK NEST BOX LOCATIONS LOWER RESERVOIR

Figure 2-10 | Date: 8/06 | Project No: 162662.000100

R:\Projects\GIS_2004\02198_FAA\studysamp_mxd\Figure_3-2.mxd number of samples). Outliers were only eliminated from a data set if justification could be provided (based on best professional judgment) that the outlier data are in error (e.g., entered incorrectly in field notebook) or no longer represent valid observations from the original sample space (e.g., sample location altered by external factor). Significant differences between means of different yearly sampling events were determined via ANOVA or the non-parametric Kruskal-Wallis ANOVA test as appropriate.

A statistical trends analysis was conducted when appropriate (i.e., sufficient statistical data available). Mercury trends were analyzed using the non-parametric Mann-Kendall Test. The Mann-Kendall test is particularly useful because missing values are allowed and the data do not need to conform to any distribution type. The non-parametric Mann-Kendall test for trend (Gilbert, 1987) is denoted by the Mann-Kendall statistic (S), where S is calculated:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign\left(x_j - x_k\right)$$

When there are multiple observations per time period, the variance of S is calculated as follows:

$$VAR(S) = 1/18\left[n(n-1)(2n+5) - \sum_{p=1}^{g} t_p(t_p-1)(2t_p+5) - \sum_{q=1}^{h} u_q(u_q-1)(2u_q+5)\right] + \frac{\sum_{p=1}^{g} t_p(t_p-1)(t_p-2)\sum_{q=1}^{h} u_q(u_q-1)(u_q-2)}{9n(n-1)(n-2)} + \frac{\sum_{p=1}^{g} t_p(t_p-1)\sum_{q=1}^{h} u_q(u_q-1)}{2n(n-1)}$$

where g is the number of tied groups and t_p is the number of ties in the pth value, h is the number of time periods that contain multiple data, and u_q is the number of multiple data in the qth time period. Then S and VAR(S) are used to compute the test statistic Z where:

$Z = (S-1)/[VAR(S)]^{0.5}$; if S > 0;
$Z = 0$; if S = 0; and
$Z = (S+1)/[VAR(S)]^{0.5}$ if S < 0.

The critical value for $Z_{0.95,}$ as obtained from a cumulative normal distribution table is 1.645 (-1.645). Positive z values larger than the critical value and negative z values smaller than the critical value indicate increasing and decreasing trends, respectively.

2.7 Risk Analyses

Forage fish and average-sized fish mercury concentrations were also evaluated to determine risk to piscivorous birds (i.e., belted kingfisher, osprey) and mammals (e.g., mink) that prey upon fish at the Upper and Lower Reservoirs. Exposure factors for the belted kingfisher, osprey and mink presented in the Supplemental RI/ERA (TRC, 2010) were used to estimate risk based on specific biota prey mercury concentrations on a yearly basis. Toxicity reference values for the avian receptors and mink are based on adverse behavioral and reproductive effects noted in a three generation study of mallards (Heintz, 1979) and neurotoxicity/mortality in mink (Chamberland et al., 1996), respectively. In addition, fish whole-body, tree swallow egg and northern long-eared bat hair mercury concentrations were compared to applicable benchmark fish whole-body, avian egg or bat hair concentrations.

3.0 BIOMONITORING RESULTS

3.1 Zooplankton Biomonitoring

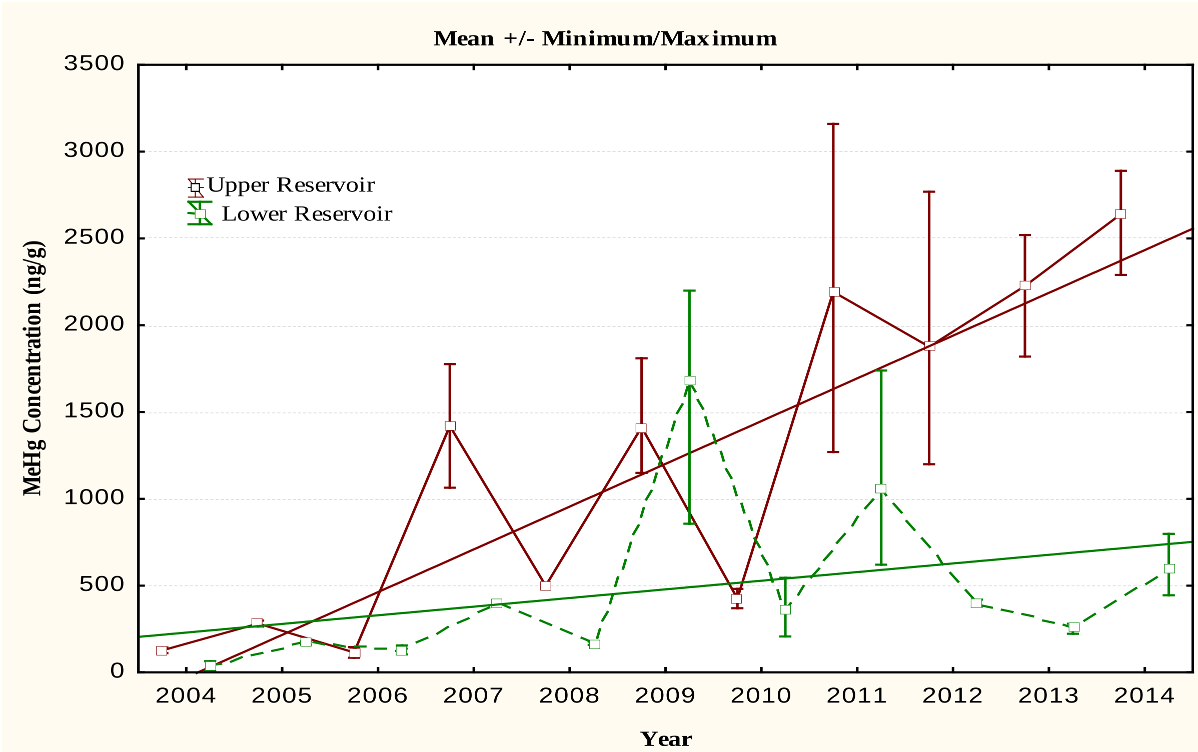
Methylmercury results from the zooplankton biomonitoring samples collected in the fall of 2005 through 2014 as well as the fall 2004 samples collected for the Supplemental RI/ERA (TRC, 2010) were evaluated with respects to trends. A minimum of two samples were collected within the Upper and Lower Reservoirs during each of the sampling events except during 2004 and 2007 (when one zooplankton sample was obtained from the Lower Reservoir) and in 2008 (when only one zooplankton sample was obtained from the Upper Reservoir). The methylmercury results from these samples are presented in Table 3-1 and Figure 3-1.

Table 3-1.
Summary Statistics for Zooplankton Samples, Fall 2004 – 2014

Year	Upper Reservoir Methylmercury Concentrations (ng/g)							
	PLK-1	PLK-2	PLK-3	Mean	Median	Variance	Std. Deviation	Std. Error
2004	111	144	-	127.5	127.5	544	23.3	16.5
2005	298.9	265.2	-	282.1	282.1	570	23.9	16.9
2006*	146.2	85.3	-	115.8	115.8	1854	43.1	30.4
2007	1,064.8	1,776.2	-	1420	1420	253045	503	356
2008	-	500	-	500	500	-	-	-
2009	1,280	1,150	1,810	1433	1280	122233	350	202
2010	370	482	-	426	426	6272	79.2	56.0
2011	3,160	2,150	1,270	2193	2150	894433	946	546
2012	1,200	2,770	1,660	1877	1660	651433	807	466
2013	2,340	2,520	1,820	2227	2340	132133	364	210
2014	2,890	2,740	2,290	2640	2740	97500	312	180
Lower Reservoir Methylmercury Concentrations (ng/g)								
2004	55.6	6.9	64.8	42.4	55.6	968	31.1	18.0
2005	179.6	160.1	-	169.9	169.9	190.9	13.8	9.8
2006*	155.8	104.6	-	130.2	130.2	1311	36.2	25.6
2007	400	-	-	400	400	-	-	-
2008	178.0	159.0	-	168.5	168.5	180.5	13.4	9.5
2009	857.0	1,980	2,200	1679	1980	518863	720	416
2010	208.0	316.0	546.0	346.7	316.0	2980	173	99.7
2011	621	835	1,740	1065	835	352830	594	343
2012	420	388	380	396	388	448	21.2	12.2
2013	269	223	281	257.7	269	937	30.6	17.7
2014	799	568	445	604	568	32301	180	104

Notes: All concentrations presented in dry weight.
*Concentrations converted to dry weight based on average moisture content of 2004 and 2005 samples.

Figure 3-1.
Mean and Minimum/Maximum Methylmercury Concentrations (ng/g dry weight) for Zooplankton Samples, Upper and Lower Reservoirs, 2004-2014



Data collected from the Upper Reservoir was normally distributed while results from the Lower Reservoirs were not normally distributed. Therefore, differences between yearly mean concentrations within the Upper and Lower Reservoirs were tested by the ANOVA and the non-parametric Kruskal-Wallis ANOVA, respectively. Methylmercury concentrations increased substantially in 2007, 2009 and 2011 in zooplankton samples collected in both the Upper and Lower Reservoirs. Concentrations of methylmercury detected in 2012 and 2013 within plankton collected from the Upper Reservoir remained high while concentrations decreased in Lower Reservoir plankton. Significant differences in mean methylmercury concentrations were noted in the Upper Reservoir ($p = 0.0003$) and for the Lower Reservoir ($p = 0.004$). A post-hoc Tukey test found significantly greater methylmercury concentrations in zooplankton samples collected from the Upper Reservoir in 2011, 2013 and 2014 compared to levels detected in 2004, 2005 and 2006 while 2013 and 2014 levels were also significantly greater than the 2010 concentration. A multiple comparison of mean ranks test for the Lower Reservoir indicated significantly higher concentrations of methylmercury were detected in 2009 than detected in 2004.

A Mann-Kendall test with multiple observations found evidence of a significantly increasing trend ($\alpha \leq 0.05$) in methylmercury concentrations within zooplankton sampled from the Upper

Reservoir (Z = 4.46; S = 202) and the Lower Reservoir (Z = 2.72; S = 138) over the 11 years of biomonitoring. However, if only evaluating the results for the past four years (2011 – 2014) when the surface water elevation of the Upper Reservoir was at full capacity, no significant trend in methylmercury is present for either the Upper Reservoir (Z = 0.22; S = 14) or the Lower Reservoir (Z = 0.25; S = -16).

3.2 Forage Fish Biomonitoring

Forage fish were collected from the Upper Reservoir (six samples located in different locations) and Lower Reservoir (five samples located in different locations) in early fall of 2005 through 2014 as a component of the biomonitoring studies. In addition, forage fish were also collected in 2002 during the initial ecological risk assessment conducted for Area U (TRC, 2004) as well as in 2004. The total mercury sampling results from 2005 through 2014 as well as earlier sampling events (2002 and 2004) are presented in Tables 3-2 and 3-3 while a graph of the mean and observed minimum and maximum detected concentrations for forage fish mercury concentrations within the Lower and Upper Reservoirs is presented in Figure 3-2. Forage fish data were not normally distributed within the Upper Reservoir or within the Lower Reservoir.

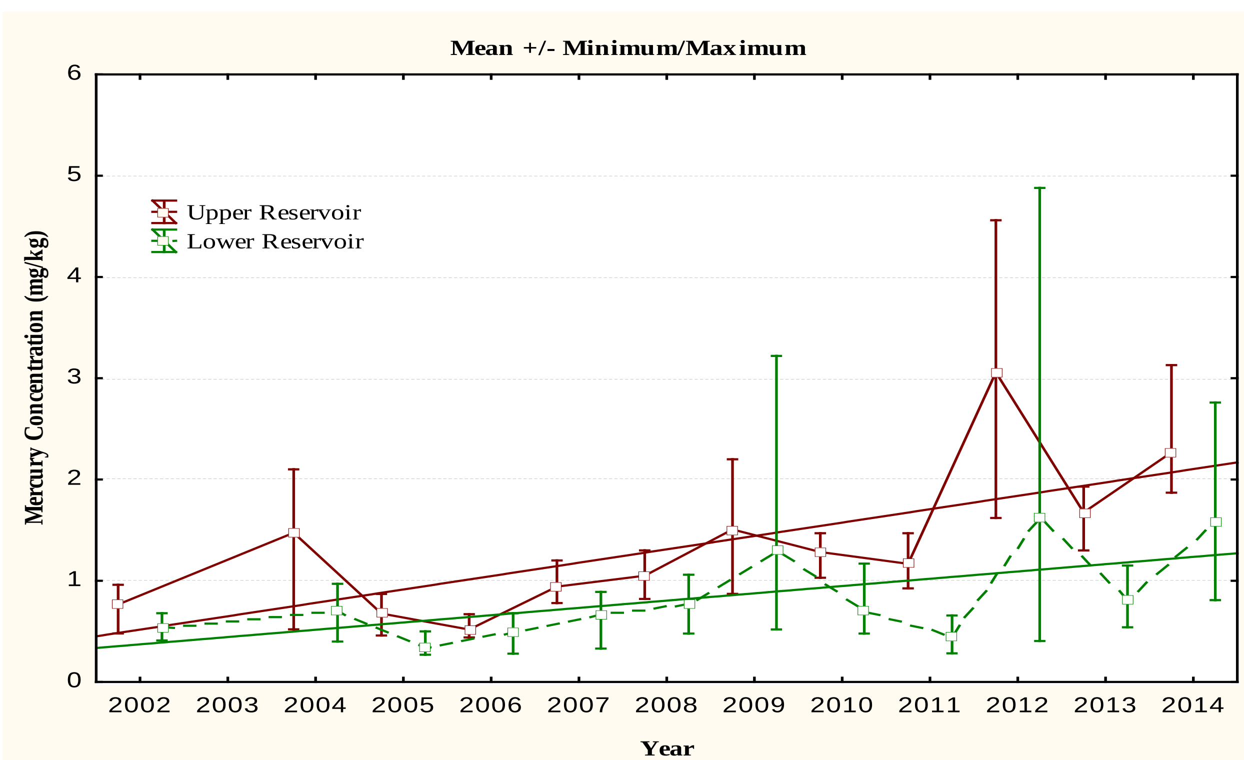
Table 3-2.
Mercury Concentrations within Forage Fish, Upper Reservoir, 2002-2014

Sample	Mercury Concentrations (mg/kg wet weight)											
	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
UR-FF-1	0.48	0.52	0.63	0.54	0.82	0.968	1.16	1.03	0.925	2.16	1.30	2.15
UR-FF-2	0.59	1.80	0.76	0.49	0.83	1.07	0.87	1.14	1.09	3.83	1.61	1.98
UR-FF-3	0.88	2.10	0.87	0.67	0.78	1.04	2.20	1.36	1.47	3.07	1.54	2.45
UR-FF-4	0.92	-	0.82	0.51	1.20	1.10	1.41	1.36	1.18	1.62	1.81	2.03
UR-FF-5	0.96	-	0.52	0.46	1.10	1.30	1.25	1.47	1.35	3.11	1.93	1.87
UR-FF-6	-	-	0.46	0.44	0.92	0.82	2.15	1.34	0.99	4.56	1.86	3.13
Mean	0.77	1.47	0.68	0.52	0.94	1.05	1.51	1.28	1.17	3.06	1.68	2.27
Median	0.88	1.80	0.70	0.50	0.88	1.06	1.33	1.35	1.14	3.09	1.71	2.09
Variance	0.05	0.70	0.03	0.01	0.03	0.02	0.30	0.03	0.04	1.15	0.06	0.22
S.D.	0.22	0.84	0.17	0.08	0.17	0.16	0.55	0.16	0.21	1.07	0.24	0.47
Std. Error	0.10	0.48	0.07	0.03	0.07	0.06	0.22	0.07	0.09	0.44	0.10	0.19

Table 3-3.
Mercury Concentrations within Forage Fish, Lower Reservoir, 2002-2014

Sample	Mercury Concentrations (mg/kg wet weight)											
	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LR-FF-1	0.41	0.97	0.27	0.68	0.89	0.62	3.22	0.55	0.38	0.55	0.56	1.42
LR-FF-2	0.49	0.40	0.32	0.58	0.33	1.06	0.87	0.48	0.45	0.70	1.15	1.76
LR-FF-3	0.58	0.82	0.39	0.40	0.60	0.95	0.75	0.71	0.28	0.40	0.84	0.81
LR-FF-4	0.68	0.61	0.50	0.28	0.83	0.76	0.52	1.17	0.66	1.56	0.94	2.76
LR-FF-5	0.55	0.72	0.29	0.51	0.69	0.48	1.19	0.65	0.46	4.88	0.54	1.19
Mean	0.54	0.70	0.35	0.49	0.67	0.77	1.31	0.71	0.44	1.62	0.81	1.59
Median	0.55	0.72	0.32	0.51	0.69	0.76	0.87	0.65	0.45	0.70	0.84	1.42
Variance	0.01	0.05	0.01	0.02	0.05	0.06	1.20	0.07	0.02	3.53	0.07	0.55
S.D.	0.10	0.22	0.09	0.16	0.22	0.24	1.09	0.27	0.14	1.88	0.26	0.74
Std. Error	0.04	0.10	0.04	0.07	0.10	0.11	0.49	0.12	0.06	0.84	0.12	0.33

Figure 3-2.
Mean and Minimum/Maximum Concentrations (mg/kg wet weight) of Mercury within Forage Fish within Upper and Lower Reservoirs, 2002-2014



Differences between yearly mean mercury concentrations within the forage fish collected from the Upper and Lower Reservoirs were tested by the non-parametric Kruskal-Wallis ANOVA and found to be significantly different. The mean mercury level detected in forage fish samples collected in 2012, 2013, and 2014 within the Upper Reservoir were significantly different (higher) than mean levels noted in 2006, while mercury concentrations in forage fish collected in 2012 and 2014 were significantly higher than noted in 2002 and 2005. In addition, the high concentrations noted in 2012 were significantly different than concentrations detected in Upper Reservoir forage fish in 2007. For the Lower Reservoir, the mean mercury concentrations noted in 2014 forage fish samples were significantly higher than levels detected in the 2005 and 2011 samples.

The Mann-Kendall Test concluded that a significant increasing trend ($\alpha \leq 0.05$) was present within mercury levels within forage fish sampled from both the Upper Reservoir (Z = 7.07; S = 1,330) and the Lower Reservoir (Z = 3.06; S = 479) over the 12 years of biomonitoring. A significantly increasing trend is also present for mercury levels within Upper Reservoir (Z = 2.34; S = 92) and Lower Reservoir (Z = 2.99; S = 90) forage fish collected over the past four years (2011 – 2014) since the Upper Reservoir was at full capacity after completion of the dam repairs in 2011.

3.3 Average-Sized Fish Biomonitoring

3.3.1 Mercury Concentrations

Average-sized fish representing the most common species present were collected from the Upper and Lower Reservoirs in early fall of 2005 through 2014. In addition, average-sized fish collected in 2004 for the Supplemental RI/ERA (TRC, 2010) were also evaluated. Summary statistics for mercury concentrations as well as length (mm) and weight (g) of fish analyzed within the Upper and Lower Reservoirs for 2004 through 2014 are presented in Tables 3-4 and 3-5, respectively. Complete results for each individual fish retained for analysis (includes the length, weight, and capture location for all average-sized fish) are presented in Attachment A.

A graph of mean mercury levels (with detected minimums/maximums) for average-sized bluegill, chain pickerel, largemouth bass and yellow perch collected from the Upper and Lower Reservoirs from 2004 through 2014 are depicted in Figures 3-3 through 3-6.

Table 3-4.
Summary Statistics for Average-Sized Fish Collected from Upper Reservoir, 2004 – 2014

Fish Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Bluegill											
Length - Mean	210.3	204.2	205.7	203.5	202.8	207.3	205.7	205.2	204.7	203.5	207.8
Weight - Mean	201.7	181.7	174.2	188.3	193.3	180.5	180.0	168.3	171.7	174.7	200.8
Mercury Stats.											
Mean	1.25	1.06	1.15	1.06	1.19	1.21	1.54	1.33	2.83	1.61	1.91
Median	1.25	1.05	1.10	1.05	1.22	1.16	1.45	1.34	3.10	1.48	2.06
Minimum	1.00	0.90	0.98	0.83	0.79	0.63	1.22	0.934	0.97	1.00	1.10
Maximum	1.50	1.20	1.40	1.20	1.64	1.83	1.96	1.62	3.84	2.34	2.62
Variance	0.04	0.02	0.03	0.02	0.09	0.16	0.07	0.05	0.99	0.29	0.32
Std. Deviation	0.19	0.13	0.17	0.14	0.3	0.40	0.26	0.23	0.99	0.54	0.56
Std. Error	0.08	0.05	0.07	0.06	0.12	0.16	0.11	0.10	0.41	0.22	0.23
Chain Pickerel											
Length - Mean	323.8	326.5	379.5	349.5	358.5	339.3	328.5	339.5	343.7	326.5	345.5
Weight - Mean	255.0	230.0	317.5	268.3	257.2	204.7	203.0	211.7	196.7	185.3	250.8
Mercury Stats.											
Mean	2.37	2.00	1.75	1.95	3.22	1.92	2.60	3.07	6.96	5.04	5.16
Median	1.95	2.00	1.75	1.90	3.12	1.83	2.76	2.86	6.91	4.98	4.86
Minimum	1.80	1.80	1.50	1.80	2.86	1.70	1.40	2.49	6.28	4.50	4.64
Maximum	3.70	2.20	2.00	2.20	3.78	2.25	3.29	4.03	7.76	5.91	6.24
Variance	0.64	0.02	0.06	0.02	0.19	0.04	0.46	0.32	0.30	0.23	0.41
Std. Deviation	0.80	0.14	0.24	0.14	0.44	0.21	0.68	0.57	0.55	0.48	0.64
Std. Error	0.33	0.06	0.12	0.06	0.22	0.09	0.28	0.23	0.22	0.19	0.26
Largemouth Bass											
Length - Mean	232.7	236.2	244.0	245.2	263.8	241.0	265.3	265.7	252.0	262.7	270.8
Weight - Mean	136.7	148.3	185.8	175.0	254.5	167.7	247.8	251.7	181.7	227.3	261.7
Mercury Stats.											
Mean	1.82	1.92	1.70	2.37	2.91	2.26	2.86	3.59	7.82	5.42	5.16
Median	1.80	1.90	1.70	2.20	2.88	2.05	3.00	3.59	7.54	5.65	5.14
Minimum	1.40	1.60	1.20	1.90	2.28	1.71	1.93	2.96	4.82	4.32	3.58
Maximum	2.30	2.20	2.30	3.20	3.52	3.24	3.37	4.07	10.8	6.02	6.23
Variance	0.09	0.08	0.15	0.22	0.18	0.31	0.25	0.15	3.83	0.38	1.08
Std. Deviation	0.29	0.28	0.38	0.47	0.43	0.56	0.50	0.39	1.96	0.61	1.04
Std. Error	0.12	0.11	0.16	0.19	0.18	0.23	0.20	0.16	0.80	0.25	0.42

Table 3-5.
Summary Statistics for Average-Sized Fish Collected from Lower Reservoir, 2004 – 2014

Fish Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Bluegill											
Length - Mean	168.8	168.8	156.3	166.2	166.2	162.2	157.2	160.8	161.2	161.6	154.8
Weight - Mean	67.5	86.2	71.3	100.0	87.0	81.0	65.6	72.0	69.0	76.0	77.8
Mercury Stats.											
Mean	0.47	0.50	0.38	0.61	0.60	0.55	0.62	0.60	0.91	0.49	0.69
Median	0.44	0.54	0.40	0.55	0.59	0.51	0.67	0.61	0.87	0.46	0.68
Minimum	0.23	0.29	0.30	0.15	0.53	0.34	0.48	0.35	0.69	0.40	0.51
Maximum	0.76	0.63	0.44	1.20	0.67	0.82	0.71	0.82	1.13	0.57	0.82
Variance	0.05	0.02	0.00	0.19	0.00	0.04	0.01	0.03	0.04	0.01	0.02
Std. Deviation	0.22	0.16	0.06	0.43	0.06	0.20	0.10	0.17	0.20	0.07	0.13
Std. Error	0.11	0.08	0.03	0.22	0.03	0.10	0.04	0.08	0.09	0.03	0.06
Chain Pickerel											
Length - Mean	341.8	332.2	359.8	330.2	362.0	349.0	357.6	353.2	364.6	355.0	352.8
Weight - Mean	181.3	190.0	256.3	166.2	258.8	223.5	234.8	217.0	230.0	218.6	225.0
Mercury Stats.											
Mean	1.25	1.10	1.28	0.96	1.71	1.12	1.71	2.70	3.72	1.88	2.94
Median	1.10	1.25	1.30	0.98	1.69	1.12	1.66	2.99	3.65	1.73	3.43
Minimum	1.00	0.52	0.64	0.76	1.42	0.773	1.61	1.30	3.14	1.58	1.37
Maximum	1.80	1.40	1.90	1.10	2.05	1.48	1.91	3.57	4.74	2.35	3.85
Variance	0.14	0.16	0.27	0.03	0.08	0.08	0.01	0.83	0.43	0.10	1.03
Std. Deviation	0.38	0.40	0.52	0.17	0.29	0.29	0.12	0.91	0.65	0.32	1.01
Std. Error	0.19	0.20	0.26	0.09	0.14	0.14	0.05	0.41	0.29	0.14	0.45
Largemouth Bass											
Length - Mean	289.0	285.5	285.0	285.0	288.5	296.8	285.6	294.8	287.8	288.8	279.7
Weight - Mean	293.3	312.5	263.8	296.2	306.8	310.0	264.2	308.0	271.3	303.0	255.3
Mercury Stats.											
Mean	1.53	0.97	1.55	1.24	1.71	1.25	1.46	1.94	3.05	1.89	2.55
Median	1.40	0.86	1.55	1.20	1.39	1.21	1.45	1.85	3.10	1.89	2.81
Minimum	1.40	0.77	1.50	0.98	1.20	1.15	1.39	1.77	2.75	1.53	1.68
Maximum	1.80	1.40	1.60	1.60	2.86	1.44	1.56	2.16	3.25	2.25	3.17
Variance	0.05	0.08	0.00	0.07	0.60	0.02	0.00	0.03	0.05	0.26	0.60
Std. Deviation	0.23	0.29	0.06	0.27	0.77	0.13	0.07	0.17	0.21	0.51	0.78
Std. Error	0.13	0.15	0.03	0.14	0.39	0.06	0.03	0.07	0.11	0.36	0.45
Yellow Perch											
Length - Mean	212.5	216.8	217.8	192.2	219.0	216.0	215.0	214.6	217.8	218.0	217.4
Weight - Mean	82.5	96.2	107.5	71.2	114.0	105.2	102.2	110.0	114.0	101.0	138.2
Mercury Stats.											
Mean	1.14	1.00	1.01	0.82	0.95	0.72	1.32	1.54	1.54	1.31	2.08
Median	1.15	0.98	1.00	0.68	0.99	0.74	1.36	1.40	1.40	1.56	2.36
Minimum	0.78	0.86	0.94	0.40	0.76	0.267	1.12	0.88	0.88	0.67	0.88
Maximum	1.50	1.20	1.10	1.50	1.08	1.12	1.56	2.57	2.57	1.86	2.79
Variance	0.09	0.02	0.00	0.22	0.02	0.17	0.03	0.40	0.40	0.30	0.54
Std. Deviation	0.30	0.14	0.07	0.47	0.14	0.41	0.18	0.63	0.63	0.55	0.73
Std. Error	0.15	0.07	0.03	0.24	0.07	0.20	0.08	0.28	0.28	0.24	0.33

Figure 3-3.
Mean, Minimum/Maximum Concentrations (mg/kg wet weight) of Mercury within Bluegills, 2004-2014

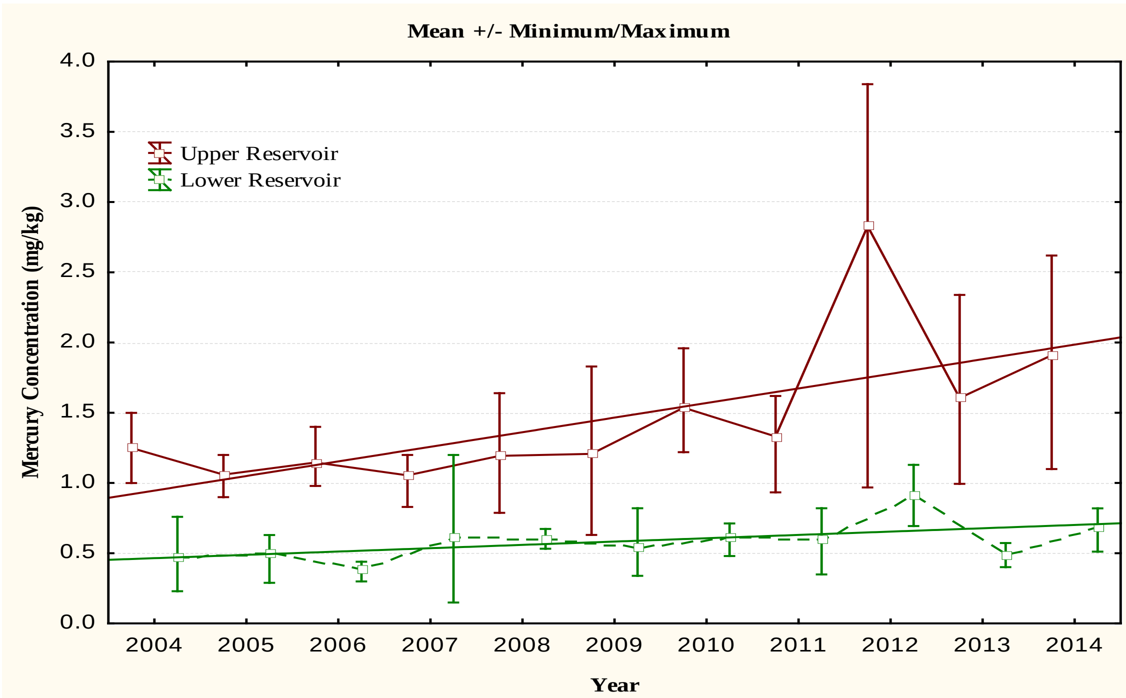


Figure 3-4.
Mean, Minimum/Maximum Concentrations (mg/kg wet weight) of Mercury within Chain Pickerel, 2004-2014

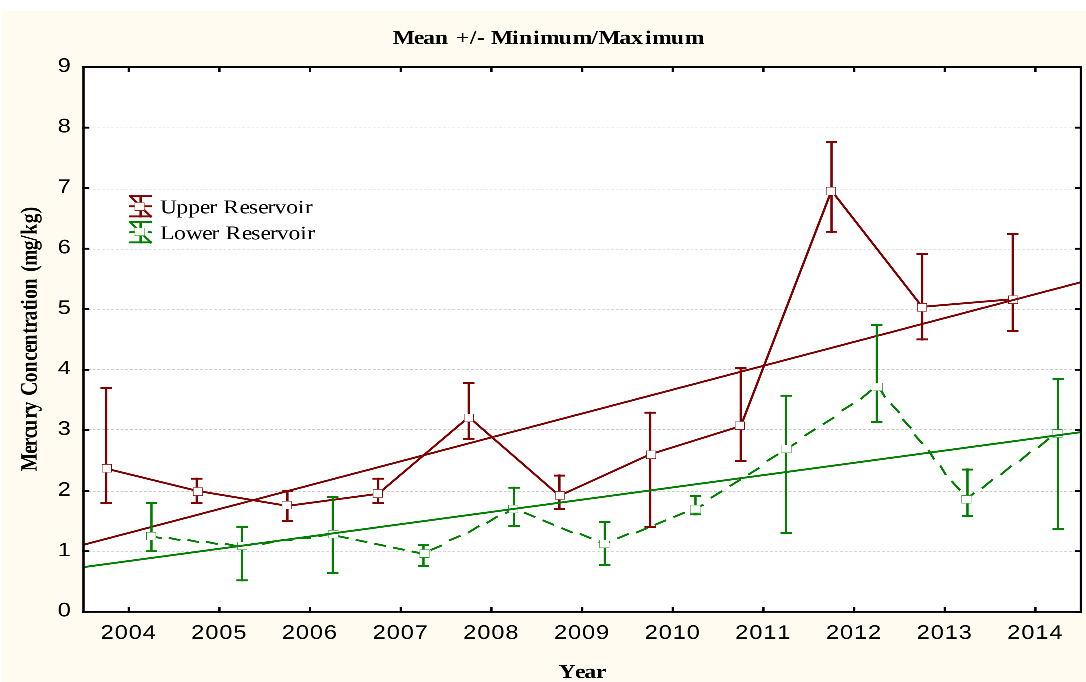


Figure 3-5.
Mean, Minimum/Maximum Concentrations (mg/kg wet weight) of Mercury within Largemouth Bass, 2004-2014

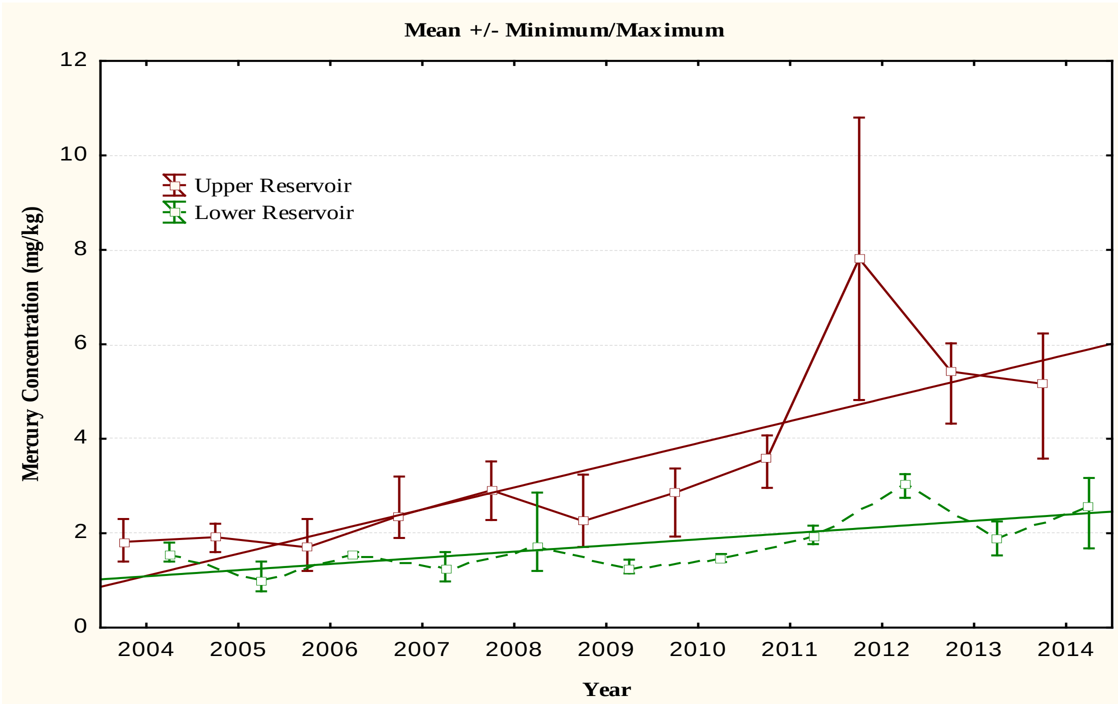
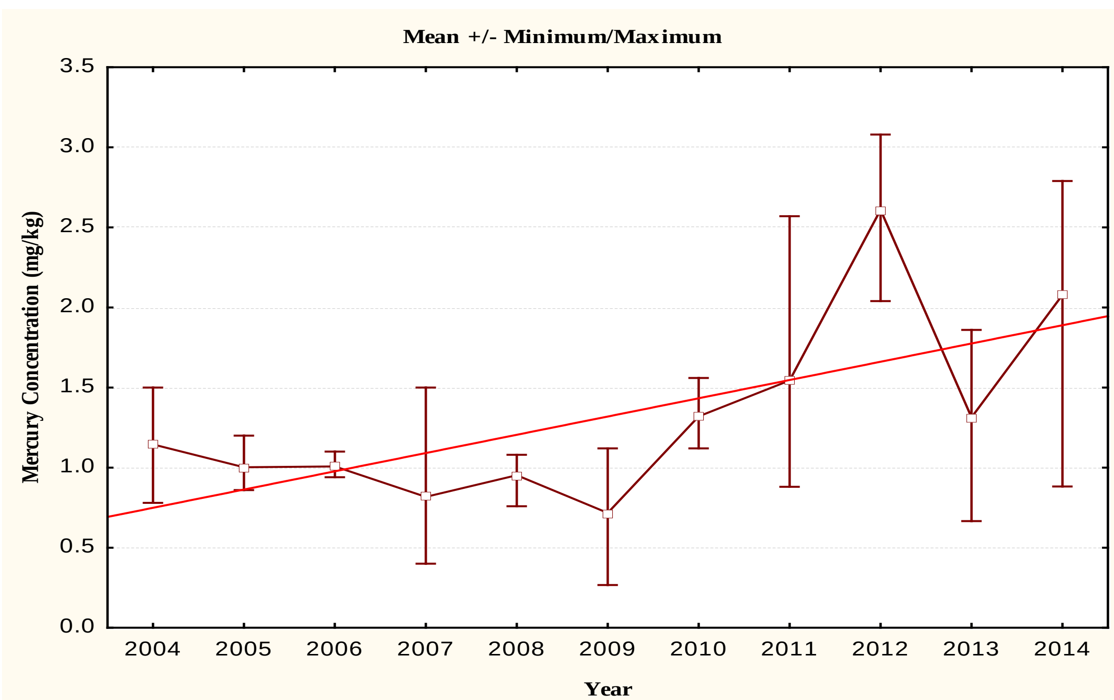


Figure 3-6.
Mean, Minimum/Maximum Concentrations (mg/kg wet weight) of Mercury within Yellow Perch, 2004-2014



For the Upper Reservoir, Kruskal-Wallis ANOVA (non-normally distributed data for all three species) found a significant difference between mean concentrations of mercury in bluegill ($p = 0.003$), chain pickerel ($p < 0.001$); and largemouth bass ($p < 0.001$) sampled within the Upper Reservoir during the 11 years of the biomonitoring. The significant difference within the Upper Reservoir bluegill concentrations is attributable to the significantly higher mean mercury concentration observed in 2012 compared to levels detected in 2005 and 2007. Significantly greater mean mercury concentrations were present in chain pickerel samples in 2012, 2013 and 2014 than levels noted in 2006 and 2009. In addition, 2012 chain pickerel mercury concentrations were also significantly greater than levels detected in 2004, 2005 and 2007. The significant difference within the Upper Reservoir largemouth bass concentrations is attributable to the significantly higher mean mercury concentration observed in 2012, 2013 and 2014 compared to levels detected in 2004, 2005 and 2006. In addition, 2012 mercury concentrations in Upper Reservoir largemouth bass are significantly greater than levels noted in 2007 and 2009.

For the Lower Reservoir, significant differences were noted in mercury concentrations within bluegill ($p = 0.02$), chain pickerel ($p = 0.001$), largemouth bass ($p < 0.001$), and yellow perch ($p = 0.004$) during the biomonitoring. The significant difference within the Lower Reservoir bluegill concentrations is attributable to the significantly higher mercury concentration observed in 2012 compared to levels detected in 2006. The significant differences within the Lower Reservoir chain pickerel and largemouth bass concentrations are attributable to the significantly higher mercury concentration observed in 2012 compared to levels detected in 2005, 2007 and 2009. The significant difference in yellow perch levels is attributable to the significantly higher levels of mercury noted in 2012 versus 2007 and 2009 concentrations.

The Mann-Kendall Test concluded that a significantly increasing trend is present for mercury concentrations in bluegill ($Z = 4.05$; $S = 729$), chain pickerel ($Z = 5.92$; $S = 969$), and largemouth bass ($Z = 7.53$; $S = 1,355$) within the Upper Reservoir. A significantly increasing trend in mercury concentrations was also noted in bluegill ($Z = 2.74$; $S = 317$), chain pickerel ($Z = 5.18$; $S = 599$), largemouth bass ($Z = 4.57$; $S = 466$) and yellow perch ($Z = 3.67$; $S = 424$) sampled within the Lower Reservoir. No significant trends are present within average-size fish at either reservoir if only the last four years of data are evaluated.

3.3.2 Condition Factors

Fulton condition factors (K) for bluegills, chain pickerel and largemouth bass within both reservoirs and yellow perch at the Lower Reservoir were calculated for each year of the biomonitoring period (2005 – 2014) and compared with each other as well as the condition factors noted in the 2004 fish community study (TRC, 2010). These results are presented in Table 3-6.

Table 3-6.
Fulton Condition Factors (K) for Bluegills, Chain Pickerel, Largemouth Bass and Yellow Perch from the Upper and Lower Reservoirs, 2004 - 2014.

Reservoir/	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014	
Species/Size	#	K	#	K	#	K	#	K	#	K	#	K	#	K	#	K	#	K	#	K	#	K
Upper Reservoir																						
Bluegill																						
<150mm	104	1.96	1	1.71	3	1.66	4	2.62	0	-	1	2.25	1	1.70	2	1.52	6	1.87	7	1.95	7	2.33
150 - 200mm	424	2.07	8	1.84	10	1.89	36	2.21	7	2.16	25	1.90	2	2.12	13	1.80	31	1.99	96	1.97	90	2.15
>200mm	657	2.25	56	2.01	111	2.11	75	2.10	41	2.16	58	1.98	69	1.94	88	1.97	80	1.94	62	1.96	44	2.07
Chain Pickerel																						
<350mm	38	0.61	6	0.56	4	0.55	5	0.65	2	0.50	12	0.51	10	0.52	6	0.54	13	0.48	28	0.54	16	0.58
350-450mm	58	0.55	9	0.56	7	0.54	18	0.62	18	0.52	12	0.53	25	0.53	21	0.53	32	0.48	36	0.49	48	0.55
>450mm	31	0.53	3	0.50	2	0.50	5	0.56	8	0.52	3	0.51	6	0.54	2	0.47	9	0.48	8	0.51	6	0.49
Largemouth Bass																						
<300mm	234	1.16	18	1.12	31	1.32	58	1.32	43	1.30	25	1.21	27	1.29	19	1.33	61	1.12	34	1.24	8	1.31
300-400mm	575	1.11	6	1.09	65	1.14	46	1.20	57	1.20	67	1.16	63	1.24	74	1.20	52	1.12	86	1.17	45	1.23
>400mm	22	1.07	0	-	7	1.10	10	1.17	17	1.13	10	1.00	3	1.16	5	1.07	8	1.15	24	1.25	3	1.25
Lower Reservoir																						
Bluegill																						
<150mm	569	1.83	4	1.52	18	2.01	8	1.95	1	1.99	1	1.75	4	1.68	0	-	2	1.82	6	1.68	8	2.74
150 - 200mm	936	1.93	39	1.78	39	1.99	27	2.15	15	1.99	13	1.85	20	1.82	36	1.87	42	1.79	78	1.82	77	2.19
>200mm	221	2.05	21	1.91	30	2.03	9	2.34	23	2.07	21	1.98	16	1.90	52	1.87	37	1.92	44	1.83	46	2.06
Chain Pickerel																						
<350mm	221	0.52	14	0.52	9	0.56	9	0.55	4	0.56	7	0.52	25	0.51	9	0.50	7	0.49	24	0.49	18	0.55
350-450mm	192	0.50	30	0.54	14	0.52	8	0.48	16	0.53	9	0.48	18	0.50	24	0.49	30	0.48	29	0.48	23	0.49
>450mm	46	0.50	7	0.50	11	0.47	4	0.48	8	0.51	4	0.43	2	0.46	6	0.47	4	0.48	9	0.47	5	0.56
Largemouth Bass																						
<300mm	130	1.23	18	1.23	13	1.21	13	1.36	9	1.25	6	1.23	15	1.14	10	1.16	12	1.16	10	1.26	7	1.35
300-400mm	387	1.17	22	1.14	42	1.16	26	1.15	25	1.18	28	1.14	45	1.19	33	1.15	46	1.13	54	1.17	19	1.17
>400mm	62	1.20	6	1.20	7	1.25	4	1.22	10	1.21	4	1.16	7	1.19	2	1.13	6	1.13	12	1.18	2	1.01
Yellow Perch																						
≤200mm	281	1.07	18	0.92	17	1.24	18	1.03	9	1.06	4	1.07	13	0.99	10	0.94	9	1.00	11	0.92	13	1.40
>200mm	403	1.09	10	1.01	31	1.09	15	1.13	31	1.09	27	1.07	37	1.05	37	1.01	61	1.02	28	1.06	21	1.22

Note: # refers to the number of fish measured/weighed to develop K for that size class for each species.

3.4 Bat Community Biomonitoring

Biomonitoring of bats at the FAA Technical Center from 2002 through 2004, from 2006 through 2012, and in 2014 involved the collection of northern long-eared bat hair samples for mercury analysis. Only four, two and eight northern long-eared bat hair samples were collected from 2002 through 2004, respectively. However, a total of 21 hair samples were collected from northern long-eared bats within or adjacent to Area U in 2006 while 36 hair samples were collected in 2007. A total of 24 hair samples were collected in 2008 while 14 hair samples were collected in 2009. A total of 39 and 29 bat hair samples were collected from northern long-eared bats at the FAA Technical Center in 2010 and 2011, respectively. In 2012, 24 hair samples were collected from northern long-eared bats and analyzed for mercury. Only two hair samples were collected from northern long-eared bats in 2014. Summary statistics of the bat hair sampling results are presented in Table 3-7.

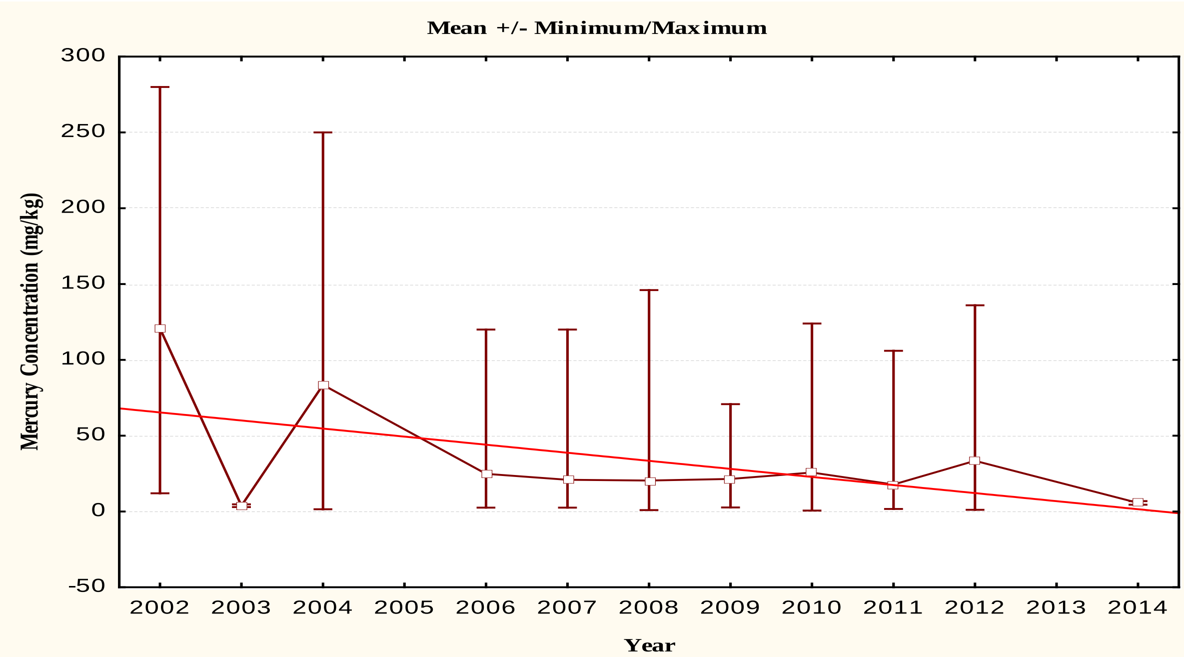
Table 3-7.
Summary Statistics of Mercury Concentrations (mg/kg wet weight) in Northern Long-eared Bat Hair Samples, 2002 – 2004, 2006 – 2012, 2014

Statistic	2002	2003	2004	2006	2007	2008	2009	2010	2011	2012	2014
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
No. Samples	4	2	8	22	36	24	14	39	30	25	2
Mean	121	3.80	83.5	24.8	20.9	20.4	21.5	25.7	17.8	33.4	5.66
Median	95.5	3.80	71.0	14.5	7.95	9.16	18.8	10.8	7.83	20.6	5.66
Minimum	12.0	2.90	1.50	2.50	2.55	0.93	2.63	0.62	1.65	1.08	4.47
Maximum	280	4.70	250	120	120	146	70.8	124	106	136	6.85
Variance	16521	1.62	7742	840	752	979	345	1184	484	1362	2.83
St. Dev.	129	1.27	88.0	29.0	27.4	31.3	18.6	34.4	22.0	36.9	1.68
Std. Error	64.3	0.90	31.1	6.18	4.57	6.39	4.97	5.51	4.06	7.38	1.19

Graphs of the mean hair and minimum/maximum concentrations are presented in Figure 3-7. A Kruskal-Wallis ANOVA found no significant difference between median concentrations of mercury in northern long-eared bat fur ($p = 0.20$) collected in the sample sets.

As evident in Figure 3-7, the mean concentration (and minimum/maximum values) exhibit a fairly steady trend as well as very high variability. The Mann-Kendall Test concluded a statistically significant increasing or decreasing trend is not present in northern long-eared bat fur samples ($Z = 0.85$; $S = -829$) collected from 2002 through 2014.

Figure 3-7.
Mean Concentrations (mg/kg wet weight) of Mercury within Northern Long-eared Bat Hair Samples Collected in 2002 – 2004, 2006 – 2012 and 2014



A number of northern long-eared bats were captured in multiple years of the study with hair samples collected during each capture and re-capture event. A total of ten northern long-eared bats were captured in two different years while one northern long-eared bat was captured during three different years of the study. The details and results of these recaptures are presented in Table 3-8. It is interesting to note that almost all of the recaptured bats were caught at the same location where they were initially captured.

3.5 Avian (Aquatic) Community Biomonitoring (Tree Swallows)

Tree swallow eggs were collected from the Upper and Lower Reservoirs in early spring of 2005 through 2009 and in 2012 through 2014. No tree swallow eggs were collected in 2010 or 2011. In addition, tree swallow eggs collected in 2004 for the Supplemental RI/ERA (TRC, 2010) were also evaluated in this comparison. Summary statistics for mercury concentrations for tree swallow eggs collected and analyzed within the Lower and Upper Reservoirs for 2004 through 2014 are presented in Table 3-9.

Table 3-8.
Northern Long-eared Bat Recapture Data, 2006 – 2012, 2014

Band No.	Initial Capture	Location	Hg - Hair	Re-Capture	Location	Hg - Hair
142	6/13/2006	Deadwood Alley	120	6/27/2007	Deadwood Alley	120 J
211	6/13/2006	Deadwood Alley	85	7/22/2008	Deadwood Alley	146
902	6/4/2007	Deadwood Alley	5.4 U	6/8/2009	Deadwood Alley	21.4
905	6/5/2007	Footbridge	4.2 J	6/14/2012	Footbridge	65.5
929	6/27/2007	Deadwood Alley	8.1 U	6/23/2011	Deer Gate	18.5
1302	6/4/2008	Blueberry Lane	4.01 U	6/24/2010	Blueberry Lane	124
1308	6/17/2008	Deer Gate	1.86 U	6/23/2009	Deer Gate	22.3
				6/23/2010	Deer Gate	115
1330	6/22/2009	Carpenter Shop	5.56	7/13/2011	Carpenter Shop	14.6
1344	6/23/2010	Deer Gate	31.8	6/28/2012	Deer Gate	53.3
1367	6/9/2011	Party Site	25.3	6/26/2012	Party Site	13.6
1392	6/23/2010	Deer Gate	2.41 J	6/28/2012	Deer Gate	31.9

Notes: Mercury hair concentrations in mg/kg (ppm).
J: Estimated Value U: Undetected

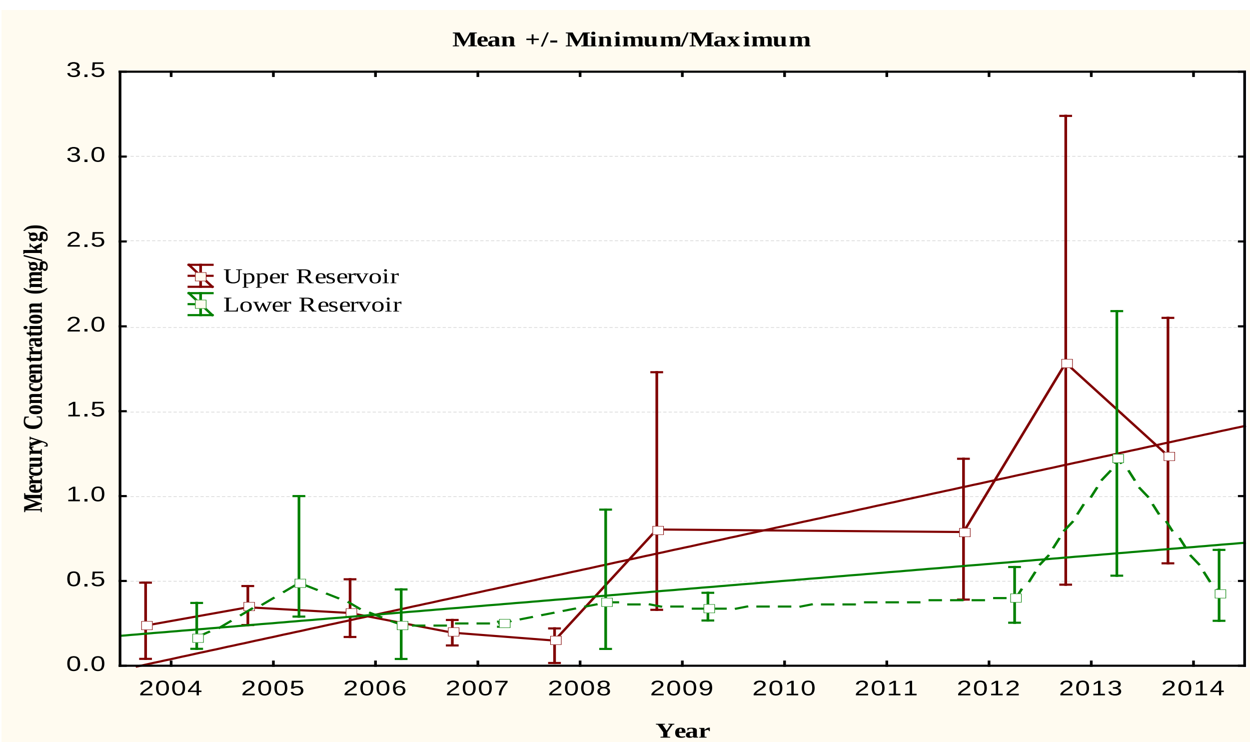
Table 3-9.
Summary Statistics for Mercury Concentrations (mg/kg wet weight) within Tree Swallow Eggs Collected from Lower and Upper Reservoirs, 2004-2014

	2004	2005	2006	2007	2008	2009	2012	2013	2014
Upper Reservoir									
Number Eggs	16	14	12	2	7	8	5	10	11
Mean	0.24	0.34	0.31	0.20	0.15	0.80	0.79	1.78	1.24
Median	0.23	0.34	0.28	0.20	0.16	0.72	0.72	1.54	1.23
Minimum	0.04	0.24	0.17	0.12	0.02	0.33	0.39	0.48	0.60
Maximum	0.49	0.47	0.51	0.27	0.22	1.73	1.22	3.24	2.05
Variance	0.02	0.01	0.01	0.01	0.00	0.22	0.11	0.92	0.27
Std. Deviation	0.14	0.07	0.12	0.11	0.07	0.47	0.33	0.96	0.52
Std. Error	0.04	0.02	0.03	0.08	0.03	0.17	0.15	0.30	0.16
Lower Reservoir									
Number Eggs	6	6	4	2	4	4	4	4	5
Mean	0.17	0.48	0.24	0.25	0.38	0.34	0.40	1.22	0.43
Median	0.14	0.37	0.24	0.25	0.24	0.33	0.38	1.14	0.46
Minimum	0.10	0.29	0.04	0.23	0.10	0.27	0.25	0.53	0.26
Maximum	0.37	1.00	0.45	0.26	0.92	0.43	0.58	2.09	0.68
Variance	0.01	0.07	0.03	0.00	0.14	0.00	0.02	0.42	0.03
Std. Deviation	0.10	0.27	0.17	0.02	0.37	0.07	0.14	0.65	0.17
Std. Error	0.04	0.11	0.08	0.02	0.19	0.03	0.07	0.33	0.08

Mercury concentrations were not normally distributed for the Upper or Lower Reservoirs. Kruskal-Wallis ANOVA found a significant difference ($p < 0.001$) between mean concentrations of mercury in tree swallow eggs collected from the Upper Reservoir over the nine year time period with the significant difference attributable to the significantly higher results noted in 2013 and 2014 compared to 2004, 2005, 2006 and 2008 and the significantly higher mercury concentrations present in tree swallow eggs in 2009 compared to 2004 and 2008. In addition, mercury levels in eggs collected in 2012 were significantly greater than concentrations noted in 2008. The mean concentrations of mercury were also found to be significantly different for the Lower Reservoir using Kruskal-Wallis ANOVA ($p = 0.009$). A multiple comparison of mean ranks test for the Lower Reservoir indicated significantly higher concentrations of mercury were detected in tree swallow eggs in 2013 than detected in 2004.

A graphical representation of the mean mercury concentrations within tree swallow eggs collected at the two reservoirs is presented in Figure 3-8. A trend analysis (with multiple observations at each time period) concluded that there were significant increasing trends in mean mercury concentrations in tree swallow eggs at the Lower Reservoir ($Z = 3.07$; $S = 206$) and the Upper Reservoir ($Z = 5.00$; $S = 1{,}056$).

Figure 3-8.
Mean, Minimum/Maximum Mercury Concentrations (mg/kg wet weight) within Tree Swallow Eggs at Lower and Upper Reservoirs, 2004 – 2014



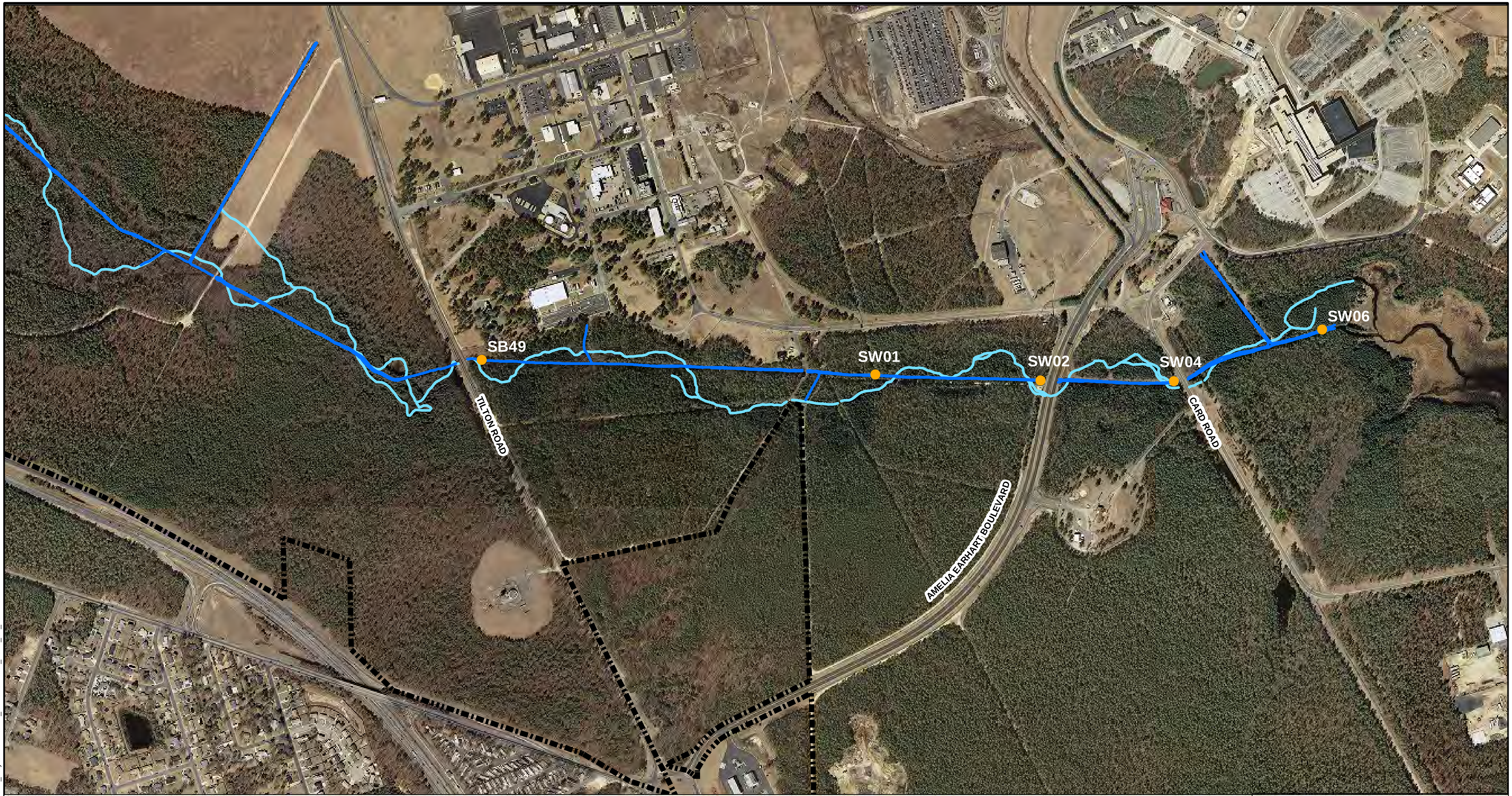
4.0 DISCUSSION

A general discussion of conditions (particularly as they relate to hydrological factors such as reservoir drawdown and precipitation) that were present within Area U during the 2002 to 2014 study period is provided within this section. Potential factors that may have affected the observed results of the biota monitoring in regards to trends and/or yearly differences are also presented. Factors previously identified as sources of variation in biota mercury levels include biogeochemical processes, environmental factors and disturbances that may affect rates of methylation and demethylation as well as food-web and trophic dynamics (Wiener et al., 2007).

4.1 Area U Hydrological Features

The SBAC represents a perennial stream that discharges into the Upper Reservoir. Surface water samples have been collected monthly from two locations within the SBAC from June 2011 through August 2013 and analyzed for mercury. Three additional SBAC sampling locations were included for mercury analysis from August 2012 through August 2013. After August 2013, these five sampling locations were only sampled quarterly. The locations of the sampling locations are depicted on Figure 4-1 while Table 4-1 presents the results of the analyses from 2011 through 2014. In general, mercury concentrations were similar between the most upgradient sample (SB49) and the two most downgradient samples (SW04 and SW06) while slightly higher concentrations were consistently noted at SW01 and SW02. However, the concentrations of mercury at all five SBAC sampling locations are approximately two orders of magnitude above the background concentration of mercury (0.00567 ug/L) detected in surface water collected from the SBAC in the vicinity of English Creek Road in May 2012.

The potential sources of the elevated mercury concentrations detected in surface water samples collected from the SBAC have been previously investigated (TRC, 2010). The results of these investigations confirmed an area of elevated mercury concentrations within the SBAC main channel with its western boundary located approximately 375 feet east (downstream) of the Building 170 gravel access road and extending downstream a distance of approximately 800 feet. Three other potential source areas were identified by groundwater seep and/or surface water sampling (TRC, 2013). The first area consists of a seep located along an abandoned SBAC meander just upstream of the SBAC main channel source area discussed above. The second area is just upstream of the Building 170 access road, where two groundwater seep samples collected from the southwestern side of the SBAC main channel exhibited mercury concentrations above background levels. The third area is located along an abandoned SBAC meander upstream of the Building 170 access road. Mercury was detected at very high levels (maximum of 185 ug/L) in seep samples collected from the northeastern side of the abandoned meander and at elevated levels in surface water samples collected immediately downstream of the seep discharge locations.



Legend

- Surface Water Sample
- SBAC Main Channel
- 1957 SBAC Stream Channel
- FAA Property Line

N
W E
S

0 350 700 1,400
Feet

Note: The orthophoto shown in this map was taken on March 19, 2001

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AREA U - BIOMONITORING STUDY

SURFACE WATER SAMPLING LOCATIONS
SOUTH BRANCH ABSECON CREEK

Figure 4-1	Date: 7/13	Project No: 162662.0000

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Table 4-1.
Mercury SBAC Surface Water Sampling Results, 2011 – 2014

Date	SB49	SW01	SW02	SW04	SW06
Jun-11		0.367	0.379		
Jul-11		0.363	0.349		
Aug-11		0.475	0.496		
Sep-11		0.358	0.351		
Oct-11		0.364	0.355		
Nov-11		0.412	0.361		
Dec-11		0.410	0.471		
Jan-12		0.523	0.873		
Feb-12		0.425	0.440		
Mar-12		0.411	0.453		
Apr-12		0.486	0.482		
May-12		0.432	0.446		
Jun-12		0.479	0.485		
Jul-12		0.515	0.490		
Aug-12	0.398	0.521	0.463	0.382	0.355
Sep-12	0.424	0.562	0.515	0.419	0.394
Oct-12	0.393	0.528	0.480	0.419	0.393
Nov-12	0.195	0.260	0.232	0.198	0.155
Dec-12	0.323	0.445	0.393	0.316	0.325
Jan-13	0.218	0.318	0.301	0.244	0.266
Feb-13	0.275	0.488	0.372	0.337	0.298
Mar-13	0.217	0.286	0.273	0.257	0.251
Apr-13	0.157	0.224	0.207	0.177	0.201
May-13	0.192	0.281	0.274	0.216	0.240
Jun-13	0.292	0.346	0.315	0.256	0.262
Jul-13	0.234	0.418	0.317	0.269	0.277
Aug-13	0.300	0.470	0.340	1.100	0.350
4th Q - 2013	0.410	0.470	0.280	0.300	0.390
1st Q - 2014	0.230	0.240	0.280	0.230	0.230
2nd Q - 2014	0.120	0.190	0.130	0.140	0.140
3rd Q - 2014	0.270	0.260	0.220	0.200	0.260
4th Q - 2014	0.180	0.260	0.240	0.230	0.110

Note: Concentrations in ug/L (ppb)

Currently, the Atlantic City Municipal Utilities Authority's (ACMUA) water supply is provided by nine ground water production wells located just north of the Upper Reservoir as well as by water drawn directly from the Lower Reservoir. Surface water outflow from the Upper

Reservoir flows directly into the Lower Reservoir. Water levels within the two reservoirs are controlled by the ACMUA and they generally manipulate water levels within the Upper Reservoir in order to maintain a near full capacity within the Lower Reservoir. In October 2004, the surface water level within the Upper Reservoir was significantly lowered due to safety concerns related to the structural integrity of its dam. This lowering of the surface water level resulted in exposure and subsequent drying of sediments within an extensive portion of this reservoir. Surface water levels within the Upper Reservoir have subsequently been lowered even further during 2007 through 2008. The surface water levels within the Upper Reservoir during 2009 did increase over levels noted in 2007, 2008 and 2010 due to greater precipitation as discussed below. ACMUA completed the reconstruction of the Upper Reservoir dam and spillway in 2011 and surface water levels were substantially higher in fall 2011 than in previous years. In 2012, the surface water levels were returned to the normal full capacity and remained full through 2013 and 2014.

In the late summer and fall of 2005, the surface water level within the Lower Reservoir was lowered by several feet due to relatively dry conditions in late summer 2005 which could not be offset by the limited capacity present within the Upper Reservoir. Surface water levels within the Lower Reservoir were back to normal levels in 2006. In the fall of 2008, the surface water level within the Lower Reservoir was temporarily lowered by several feet due to construction activities underway near its dam.

The amount of precipitation is also a factor in determining surface water levels within the SBAC and Upper Reservoir and to a lesser degree, within the Lower Reservoir. The manipulation of the water level within the Upper Reservoir also affects the surface water level within the lower portion of the SBAC.

Table 4-2 presents climatological conditions noted at the Atlantic City International Airport during 2002 and 2004 through 2014 which represent the years when biota samples used in this evaluation were collected (NOAA, 2002, 2004 through 2014). As noted in this table, the annual precipitation was $\pm$ 20% of the normal amount except during 2006, 2009 and 2014 when precipitation was nearly 25%, 50% and 30% greater than the normal amount, respectively. These data, as well as the characteristics associated with the water drawdown within the Upper Reservoir were used to evaluate potential causative factors in the observed levels of mercury/ methylmercury within the monitored biota.

Table 4-2.
Monthly Precipitation Data (2002, 2004-2014) at Atlantic City International Airport

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Total
Mean (1981-2010)													
Precipitation (inches)	3.28	2.87	4.20	3.63	3.34	3.11	3.72	4.11	3.15	3.42	3.27	3.69	41.79
# Days > 0.1inch precip.	6.0	5.8	6.8	6.9	6.4	5.7	5.7	5.6	5.6	5.3	5.6	6.5	72
# Days > 1.0inch precip.	0.8	0.7	1.1	0.9	0.5	0.8	1.1	1.1	0.7	1.2	1.0	1.0	11
2002													
Precipitation (inches)	2.08	0.74	5.60	4.08	2.74	4.98	1.07	2.43	3.30	6.37	5.96	4.31	43.66
# Days > 0.1inch precip.	6	2	9	7	6	6	3	5	6	9	10	6	75
# Days > 1.0inch precip.	0	0	1	1	0	2	0	1	1	3	3	2	14
2004													
Total Precipitation	1.55	2.15	3.45	4.71	3.29	1.81	5.21	4.14	2.30	3.49	4.42	2.55	39.07
# Days > 0.1inch precip.	5	3	7	9	7	4	4	7	5	6	6	6	69
# Days > 1.0inch precip.	0	1	0	2	0	0	2	1	1	1	3	0	11
2005													
Total Precipitation	4.01	3.23	3.68	3.40	3.53	3.90	4.43	1.02	0.53	9.04	2.80	4.38	43.95
# Days > 0.1inch precip.	6	6	4	6	5	5	9	4	2	10	7	9	73
# Days > 1.0inch precip.	1	1	1	2	1	1	1	0	0	6	0	1	15
2006													
Total Precipitation	5.83	2.22	0.37	3.45	3.58	5.05	5.20	3.68	6.32	6.09	6.64	2.24	50.67
# Days > 0.1inch precip.	5	5	1	4	6	7	5	3	7	7	7	3	60
# Days > 1.0inch precip.	2	0	0	1	1	2	2	1	2	3	2	1	17
2007													
Total Precipitation	3.41	2.36	3.52	5.47	1.39	5.18	1.77	3.51	1.37	4.76	1.40	7.21	41.35
# Days > 0.1inch precip.	5	3	6	5	3	7	4	6	2	7	5	12	65
# Days > 1.0inch precip.	1	1	1	3	0	2	0	0	0	2	0	3	13
2008													
Total Precipitation	2.18	5.27	3.06	3.25	4.59	2.28	3.40	2.44	5.30	1.60	5.94	7.27	46.58
# Days > 0.1inch precip.	6	8	4	9	5	4	4	3	7	3	8	3	64
# Days > 1.0inch precip.	0	2	1	0	1	1	2	1	2	1	3	1	15
2009													
Total Precipitation	2.76	0.68	2.53	6.23	3.43	7.05	3.86	6.99	6.94	7.97	3.12	9.99	61.55
# Days > 0.1inch precip.	5	3	5	10	9	11	6	8	7	9	8	9	90
# Days > 1.0inch precip.	1	0	0	2	0	2	1	4	3	3	1	3	20
2010													
Total Precipitation	2.76	6.50	8.64	1.49	3.22	1.71	3.12	1.08	3.45	4.37	2.10	3.69	42.13
# Days > 0.1inch precip.	3	9	10	3	4	3	5	2	5	8	2	4	58
# Days > 1.0inch precip.	2	2	2	0	1	0	1	0	1	1	1	1	12
2011													
Total Precipitation	3.19	2.93	4.52	3.55	3.33	1.62	4.15	11.11	2.95	3.00	4.52	3.65	48.52
# Days > 0.1inch precip.	7	7	7	8	5	4	4	9	7	4	6	7	75
# Days > 1.0inch precip.	0	0	1	1	0	0	1	4	0	2	1	1	11
2012													
Total Precipitation	2.35	2.39	2.10	2.93	3.56	6.20	3.38	5.59	3.52	8.09	1.34	7.15	48.60
# Days > 0.1inch precip.	5	7	6	3	9	6	4	7	6	9	3	9	74
# Days > 1.0inch precip.	0	0	1	1	1	2	1	3	1	1	0	2	13
2013													
Total Precipitation	2.30	5.16	4.66	2.74	2.70	7.53	3.40	2.93	1.18	4.91	2.55	6.06	46.12
# Days > 0.1inch precip.	5	8	8	5	5	9	7	5	4	5	5	9	75
# Days > 1.0inch precip.	0	1	2	0	1	3	0	1	0	2	1	2	13
2014													
Total Precipitation	3.25	5.30	5.00	4.37	2.26	1.54	5.09	9.91	3.52	3.22	5.37	5.54	54.37
# Days > 0.1inch precip.	9	7	8	7	5	4	9	6	7	8	5	7	82
# Days > 1.0inch precip.	0	3	1	2	0	0	1	3	1	0	3	1	15

4.2 Significant Area U Biota Monitoring Trends and Yearly Differences

Several significantly increasing or decreasing trends were noted in the biomonitoring data collected over the study period. As reported in Section 3.0, the following significant trends were observed within Area U biota that were sampled in 2014:

1. *Zooplankton* - increasing methylmercury within Upper and Lower Reservoirs (2004 – 2014);
2. *Forage Fish* – increasing mercury within Upper and Lower Reservoirs (2002 – 2014);
3. *Average-Size Fish* - increasing mercury in bluegill, chain pickerel and largemouth bass inhabiting Upper Reservoir and bluegill, chain pickerel, largemouth bass and yellow perch within the Lower Reservoir (2004 - 2014); and,
4. *Tree Swallows* – increasing levels of mercury in eggs collected within Upper and Lower Reservoirs (2004 – 2014).

Significant differences in mean mercury concentrations between different sampling years were also noted in the biomonitoring data. As reported in Section 3.0, the following significant differences in mean mercury levels were observed within Area U biota:

1. *Zooplankton* – higher methylmercury in Upper Reservoir in 2011, 2013 and 2014 vs. 2004, 2005 and 2006, and in 2013 and 2014 vs. 2010;
2. *Zooplankton* – higher methylmercury in Lower Reservoir in 2009 vs. 2004;
3. *Forage Fish* – higher mercury in Upper Reservoir 2012, 2013 and 2014 vs. 2006, and in 2012 and 2013 vs. 2002 and 2005, and in 2012 vs. 2007;
4. *Forage Fish* – higher mercury in Lower Reservoir in 2014 vs. 2005 and 2011;
5. *Bluegill* – higher mercury in Upper Reservoir in 2012 vs. 2005 and 2007;
6. *Bluegill* – higher mercury in Lower Reservoir in 2012 vs. 2006;
7. *Chain Pickerel* – higher mercury in Upper Reservoir in 2012, 2013 and 2014 vs. 2006 and 2009 and in 2012 vs. 2004, 2005 and 2007;
8. *Chain Pickerel* – higher mercury in Lower Reservoir in 2012 vs. 2005, 2007 and 2009;
9. *Largemouth Bass* – higher mercury in Upper Reservoir in 2012, 2013 and 2014 vs. 2006 and 2009, and in 2012 vs. 2004, 2005 and 2007;
10. *Largemouth Bass* – higher mercury in Lower Reservoir in 2012 vs. 2005, 2007 and 2009;
11. *Tree Swallow* – higher mercury in eggs at Upper Reservoir in 2013 and 2014 vs. 2004, 2005, 2006 and 2008, and in 2009 vs. 2004 and 2008, and in 2012 vs. 2008; and
12. *Tree Swallow* – higher mercury in eggs at Lower Reservoir in 2013 vs. 2004.

4.2.1 Zooplankton Trends and Yearly Differences

A significantly ($\alpha \leq 0.05$) increasing trend was noted in the concentration of methylmercury within zooplankton samples collected from both the Upper and Lower Reservoirs during 2004 through 2014. The highest methylmercury concentrations were noted within zooplankton samples collected from the Upper Reservoir in 2011, 2013 and 2014. The lowest methylmercury levels in zooplankton sampled from the Lower Reservoir was in 2004 prior to the drawdown while the highest methylmercury levels were noted in zooplankton collected in 2009. The level of methylmercury within Lower Reservoir zooplankton in 2009 was significantly greater than levels noted in 2004 and more than four times higher than levels noted in any year except 2011.

The increasing concentrations of methylmercury within the two reservoirs is likely attributable to the lowering of surface water levels within the Upper Reservoir beginning in fall 2004. The drawdown may have affected methylmercury concentrations within the surface water of the reservoirs through several methods. First, the smaller volume of surface water within the Upper Reservoir during 2005 – 2010 may have resulted in greater concentrations of methylmercury being present within this waterbody assuming a constant methylmercury source input (e.g., groundwater discharge to the SBAC upstream of Tilton Road). Alternatively, the large area of exposed sediment within the Upper Reservoir consisting of mercury-contaminated peat would be subject to decomposition and subsequent release of organic matter and mercury (Morrison and Therien, 1994). Periodical flooding of the mercury-contaminated peat during the period of the reservoir drawdown may also have resulted in conditions conducive to formation of methylmercury by sulfate-reducing bacteria.

In fall 2011, the complete re-inundation of the mercury-contaminated peat at the Upper Reservoir likely resulted in an initial increase in methylation of mercury during the fall of 2011 which appears to have continued through 2014. An increase in the surface water concentration of methylmercury would be expected to result in a corresponding increase in zooplankton methylmercury levels within the Upper Reservoir given the very high bioaccumulation factors associated with zooplankton and surface water methylmercury levels.

It is interesting to note that the levels of methylmercury within zooplankton within the Upper and Lower Reservoirs over the past four years since completion of the dam repairs are not trending downward. Zooplankton sampled from both the Upper and Lower Reservoirs from 2011 to 2014 contain high methylmercury concentrations with no significantly increasing or decreasing trends present. The inundation of mercury-contaminated peat in the Upper Reservoir in 2011 appears to have resulted in substantial increases in surface water methylmercury levels within the Upper and Lower Reservoirs during all four years.

The zooplankton methylmercury concentrations were compared to the community composition and the amount of precipitation in the 4, 6, 9 and 11 months prior to sample collection to determine if there was a correlation between zooplankton composition (based on relative biomass), precipitation and methylmercury concentrations. Correlation is a measure of the relation between two or more variables. Correlation coefficients can range from -1.00 to +1.00. The value of -1.00 represents a perfect negative correlation while a value of +1.00 represents a perfect positive correlation. A value of 0.00 represents a lack of correlation. A correlation greater than 0.7 or 0.8 is generally described as strong, whereas a correlation less than 0.5 is generally described as weak. The precipitation data (for all four periods) and the methylmercury results for the Upper Reservoir plankton were normally distributed while the Lower Reservoir methylmercury results were not normally distributed. The relative biomass contribution from Calanoida at both reservoirs were normally distributed while the remaining zooplankton composition (Orders Copepoda and Diplostraca) do not have a normal distribution. Therefore, the Pearson correlation (also called the product-moment correlation) was used for the Upper Reservoir analyses (except for the relative biomass of Copepoda and Diplostraca) while the nonparametric Spearman Rank Order correlation was used for the Lower Reservoir data.

For the Upper Reservoir, the Pearson correlation found a weak correlation ($r < 0.5$) between methylmercury levels in plankton and the amount of precipitation noted in the 4, 6, 9 and 11 months prior to collection of the plankton samples. The strongest correlation was noted for the relative biomass contribution from Calanoida in the zooplankton samples ($r = -0.59$) although the coefficient of determination (r^2) is only 0.35 indicating that the linear relationship between the methylmercury concentrations and the relative biomass of Calanoida only explains 35% of the total variation in the methylmercury plankton concentrations noted each year. The correlation was negative for this variable indicating that the greater the relative biomass contributed by Calanoida the lower the methylmercury concentration within the zooplankton samples.

The Spearman Rank Order correlation for the Lower Reservoir concluded that a fairly strong correlation ($r = 0.73$) exists between plankton methylmercury concentrations and precipitation received the previous nine months prior to sampling the plankton with less correlation noted with the 4, 6 and 11 month precipitation data. A fairly strong negative correlation is also present between the plankton methylmercury levels and relative biomass of the zooplankton community comprised of Calanoida. The coefficient of determination (r^2) for both these variables is 0.53 indicating that the linear relationship between the methylmercury concentrations and the prior nine month precipitation data and the relative biomass of Calanoida each explains approximately 50% of the total variation in the methylmercury plankton concentrations.

The greater correlation noted between plankton and precipitation in the Lower Reservoir compared to the Upper Reservoir is not unexpected given that the likely source(s) of mercury to the Lower Reservoir are located within the Upper Reservoir itself (mercury-contaminated sediments) or in the seeps/sediments associated with the SBAC and its meanders. The greater the amount of precipitation received within the watershed of the Lower Reservoir, the greater the increase in the discharge of surface water from the Upper Reservoir (containing methylmercury) to the Lower Reservoir.

The reason for the substantially elevated levels in 2009 may be attributable to several factors. As discussed earlier, a Spearman Rank Order correlation for the Lower Reservoir concluded that a fairly strong correlation (r = 0.73) exists between plankton methylmercury concentrations and precipitation received the previous nine months prior to sampling the plankton. In 2009, the very high amount of precipitation received in the study area resulted in an increase in surface water levels within the Upper Reservoir and some re-flooding of previously exposed sediments. This may have resulted in the production of additional methylmercury that was subsequently released to the overlying surface water and the increased precipitation resulted in a large increase in the amount of surface water discharged from the Upper Reservoir to the Lower Reservoir (E. Gratz, ACMUA, pers. comm.). The increased discharge from the Upper Reservoir (presumably containing greater concentrations of methylmercury than the Lower Reservoir) may have increased levels of methylmercury within the surface water of the Lower Reservoir, and subsequently, within the zooplankton.

Secondly, a significantly greater percentage of the zooplankton in 2009 was comprised of cladocerans (Diplostraca) compared to 2004 when copepods comprised the bulk of the zooplankton population. The concentrations of methylmercury and results of the zooplankton community analysis are presented in Table 4-3. In 2004, the presence of cladocerans was found to be significantly correlated with methylmercury concentrations in zooplankton (TRC, 2010). In 2009, cladocerans comprised approximately 67 percent (range of 50 to 85 percent) of the zooplankton samples collected at the three zooplankton samples collected from the Lower Reservoir. Conversely, less than 10 percent of the 2004 zooplankton samples were comprised of cladocerans. The Spearman Rank Order correlation for the Lower Reservoir found a fairly strong negative correlation between zooplankton methylmercury concentrations and abundance of Calanoida copepods in each sample during the entire biomonitoring. Interestingly, the relative biomass of cladocerans at the Lower Reservoir is very strongly and negatively correlated (r = -0.92) with the relative biomass of Calanoida copepods within the Lower Reservoir. A similar strong negative correlation (r = -0.82) exists between the relative biomass of cladocerans and Calanoida copepods present at the Upper Reservoir.

Table 4-3.
Methylmercury and Zooplankton Relative Biomass Summary, 2004, 2009 – 2014

Zooplankton	UR-1							UR-2							UR-3						
	2004	2009	2010	2011	2012	2013	2014	2004	2009	2010	2011	2012	2013	2014	2004	2009	2010	2011	2012	2013	2014
MeHg (ng/g)	111	1280	370	3160	1200	2340	2890	144	1150	482	2150	2770	2520	2740	-	1810	-	1270	1660	1820	2290
Copepods																					
Copepoda	3.94	5.33	4.64	28.6	3.95	0.25	2.67	2.09	17.8	-	14.9	6.11	2.81	3.88	0.93	19.9	-	-	4.51	8.69	0.63
Calanoida	86.5	44.0	82.9	41.0	70.7	17.0	13.2	84.2	56.3	-	68.7	68.0	61.0	71.5	20.2	52.5	-	-	69.5	81.6	50.9
Cyclopoida	0.00	1.28	0.00	3.48	0.00	0.00	0.00	0.00	0.00	-	4.38	0.51	0	0.00	0.00	0.00	-	-	0.00	0.00	0.00
Diplostraca	9.54	48.4	12.5	18.1	25.3	82.7	84.17	13.7	25.8	-	10.0	25.4	36.1	24.7	78.9	27.7	-	-	26.0	9.7	48.52
Podopoca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00
Rotifera	0.07	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.03	-	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00
Protozoa																					
Arcellinida	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0.00	0.00	0.00

Zooplankton	LR-1							LR-2							LR-3						
	2004	2009	2010	2011	2012	2013	2014	2004	2009	2010	2011	2012	2013	2014	2004	2009	2010	2011	2012	2013	2014
MeHg (ng/g)	55.6	857	208	621	420	269	799	6.87	1980	316	835	388	223	568	64.8	2200	546	1740	380	281	445
Copepods																					
Copepoda	3.00	0.00	0.00	2.30	14.2	1.04	7.89	0.44	0.00	2.05	22.1	16.2	2.78	4.66	-	0.94	4.17	42.7	-	3.38	0.06
Calanoida	91.0	27.1	97.4	53.5	66.1	98.0	84.8	97.9	45.5	95.7	67.6	72.1	70.1	76.0	-	13.2	81.9	35.7	-	68.1	1.38
Cyclopoida	0.00	4.65	0.71	12.9	4.73	0.00	0.00	0.00	1.54	0.00	0.00	2.61	0.00	0.00	-	0.11	0.22	5.42	-	0	0.00
Diplostraca	6.05	68.3	1.83	31.3	14.9	0.95	7.27	1.67	52.8	2.24	10.3	9.13	27.1	19.3	-	85.3	13.7	15.4	-	28.6	98.6
Podopoca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	-	0.00	0.00
Rotifera	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	-	0.00	0.01	0.02	-	0	0.00
Protozoa																					
Arcellinida	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	0.48	0.00	0.72	-	0	0.00

4.2.2 Forage Fish Trends

Forage fish samples within the Upper and Lower Reservoirs exhibited significantly increasing trends in mercury levels ($\alpha \leq 0.05$) from 2002 to 2014 and significant increasing trends were also evident from 2011 to 2014 after the water level was elevated following the dam repairs. The increasing significant trends in forage fish mercury concentrations within the Upper and Lower Reservoirs are comparable to the observed increasing significant trends in zooplankton methylmercury levels over the entire monitoring period. As forage fish would ingest zooplankton, mercury levels in forage fish would be expected to increase as the levels in zooplankton increase.

As discussed above, the surface water level within the Upper Reservoir was substantially lowered in the fall of 2004 (post-sampling of 2004 forage fish) resulting in a large area of exposed sediment that could no longer provide habitat for fish. The areas of exposed sediment correspond to areas of the Upper Reservoir where the highest sediment concentrations of mercury are present. If these contaminated sediments were directly contributing to mercury exposure to forage fish, one would have expected levels of mercury in forage fish to decline as these areas became exposed and unavailable as forage fish habitat. However, levels of mercury in forage fish actually have increased which indicates that methylmercury levels in the overlying surface water (and zooplankton) is likely responsible for this increase, although the decomposition of the exposed sediments may be contributing to the suspected increase in surface water concentrations of methylmercury.

The mean concentration of mercury detected in forage fish in 2012, 2013 and 2014 from the Upper Reservoir was significantly elevated compared to the mean concentrations detected in 2006. In addition, the levels of mercury detected in forage fish samples collected in 2012 and 2014 were significantly higher than 2002 and 2005 levels while 2012 mercury concentrations were significantly elevated above concentrations noted in 2007. Levels of mercury within forage fish collected from the Lower Reservoir in 2014 were significantly greater than concentrations noted in 2005 and 2011.

The concentrations of mercury detected in the forage fish samples were compared to the zooplankton methylmercury concentrations from that same year as well as the preceding year and the amount of precipitation in the 4, 6, 9 and 11 months prior to collection of the forage fish samples to determine if there was a correlation between plankton methylmercury concentrations, precipitation and forage fish mercury concentrations. The mercury results for the forage fish collected at the Upper and Lower Reservoirs were not normally distributed. Therefore, the nonparametric Spearman Rank Order correlation was used for both the Upper and Lower Reservoir data.

For the Lower Reservoir, the Spearman Rank Order correlation found weak correlations ($r < 0.4$) between mercury concentrations in forage fish and methylmercury levels in plankton (same year and preceding year) and the amount of precipitation noted in the 4, 6, 9 and 11 months prior to collection of the forage fish samples. The strongest correlation was noted for the 11 months prior to collection ($r = 0.34$) although the coefficient of determination (r^2) is only 0.12, indicating that the linear relationship between the mercury concentrations and the 11-month precipitation data only explains 12% of the total variation in the mercury forage fish concentrations noted each year.

The Spearman Rank Order correlation for the Upper Reservoir concluded that a strong correlation (r = 0.81) exists between forage fish mercury concentrations and methylmercury concentrations in zooplankton the year prior to collection of the forage fish samples. The coefficient of determination (r^2) is 0.65 indicating that the linear relationship between the forage fish mercury concentrations and the prior year's zooplankton methylmercury concentration data explains 65% of the total variation in the mercury forage fish concentrations. A weaker correlation (0.69) exists between the forage fish mercury levels and the plankton methylmercury concentrations sampled at the same time as the forage fish. Weak correlations (< 0.5) are present with forage fish mercury concentrations and the 4, 6, 9 and 11 month precipitation data.

4.2.3 Average-Sized Fish Trends

Elevated concentrations of mercury have been noted in fish tissue samples collected from Area U since 1993 and 1994 when New Jersey Department of Environmental Protection and Energy initially sampled largemouth bass from the Upper Reservoir and noted the concentrations of mercury detected in these samples were some of the highest noted in the state (NJDEPE, 1994). Significantly increasing trends from 2004 to 2014 are present for mercury levels within average-sized bluegill, chain pickerel and largemouth bass inhabiting the Upper Reservoir. Chain pickerel and largemouth bass are predators of smaller forage fish and the concentrations of mercury within these piscivorous species are roughly equivalent. The increasing levels of mercury in chain pickerel and largemouth bass likely correspond to the increasing levels noted in their prey (i.e., forage fish). Bluegills are omnivorous species consuming primarily macroinvertebrates. As lower trophic level fish species, bluegills would be less likely to bioaccumulate mercury than the piscivorous chain pickerel and largemouth bass. Although the concentrations of mercury detected in bluegill are below levels detected in both largemouth bass and chain pickerel, the levels in bluegills are increasing and likely reflect increasing levels in their prey.

Significantly increasing trends of mercury levels within average-sized bluegill, chain pickerel, largemouth bass and yellow perch inhabiting the Lower Reservoir are present from 2004 to 2014. As noted above, both chain pickerel and largemouth bass are predators of smaller forage fish. The increasing levels in chain pickerel and largemouth bass likely correspond to the previous increasing levels noted in their prey. Bluegills and yellow perch are omnivorous species consuming primarily macroinvertebrates and would be less likely to bioaccumulate mercury than the piscivorous chain pickerel and largemouth bass. Similar to results obtained for the Upper Reservoir, the concentrations of mercury detected in bluegill within the Lower Reservoir are below levels detected in both largemouth bass and chain pickerel. However, the mercury levels in bluegills and yellow perch inhabiting the Lower Reservoir are significantly increasing and likely reflect increasing levels in their prey.

If just evaluating the most recent four years of biomonitoring data from 2011 through 2014 after the Upper Reservoir was returned to full capacity, no significant increasing or decreasing trends are present in average-size fish sampled from the Upper and Lower Reservoirs.

4.2.3.1 Bluegill Yearly Differences

Significantly higher levels of mercury were detected in bluegills collected from the Upper Reservoir in 2012 compared to samples from 2005 and 2007. Significantly higher levels of mercury were detected in bluegills collected from the Lower Reservoir in 2012 compared to samples from 2006.

The concentrations of mercury detected in the bluegill samples were compared to the plankton and forage fish mercury concentrations (same year and previous year to collection of bluegill samples) and the amount of precipitation in the 4, 6, 9 and 11 months prior to collection of the bluegill samples to determine if there was a correlation between these factors. The number of comparable samples available for the Upper Reservoir exceeds 50 which would minimize bias in non-normally distributed data. However, less than 50 comparable data sets are available for bluegills within the Lower Reservoir and the Lower Reservoir mercury results were not normally distributed. Therefore, the Pearson correlation was used for the Upper Reservoir analyses while the nonparametric Spearman Rank Order correlation was used for the Lower Reservoir data.

For the Upper Reservoir, the Pearson correlation found a fairly strong correlation ($r = 0.74$) between mercury levels in bluegills and forage fish (same year of sampling). The coefficient of determination (r^2) is 0.55 indicating that the linear relationship between the mercury concentrations in bluegills and forage fish explains 55% of the total variation in the mercury bluegill concentrations noted each year. However, since bluegills are generally not piscivorous species that would prey on forage fish, the correlation observed between bluegills and forage fish is likely due to similar modes of exposure each year. Bluegills are omnivorous species consuming primarily macroinvertebrates while forage fish would be expected to prey on zooplankton as well as smaller invertebrates. The similarity between increasing and decreasing mercury concentrations within bluegills and forage fish is likely attributable to similar trends in their respective prey.

The Spearman Rank Order correlation for the Lower Reservoir concluded that weak correlations ($r < 0.40$) exists between bluegill mercury concentrations and all of the factors included in the analyses.

4.2.3.2 Chain Pickerel Yearly Differences

Significantly greater concentrations of mercury were noted in average-sized chain pickerel collected from the Upper Reservoir in 2012, 2013 and 2014 and from the Lower Reservoir in 2012 than in previous years. The highest concentrations were observed in 2012 within both reservoirs. The mean concentrations of mercury within the prey of pickerel (forage fish) sampled from the Upper and Lower Reservoirs in 2012 was also greater than levels noted in the preceding 10 years of sampling.

The concentrations of mercury detected in the average-sized pickerel were compared to the forage fish mercury concentrations (same year and previous year to collection of pickerel samples) and the amount of precipitation in the 4, 6, 9, and 11 months prior to collection of the samples to determine if there was a correlation between these factors. The number of comparable samples available for the Upper Reservoir exceeds 50 which would minimize bias in non-normally distributed data. However, less than 50 comparable data sets are available for chain pickerel within the Lower Reservoir and the Lower Reservoir mercury results were not normally distributed. Therefore, the Pearson correlation was used for the Upper Reservoir analyses while the nonparametric Spearman Rank Order correlation was used for the Lower Reservoir data.

For the Upper Reservoir, the Pearson correlation found a strong correlation ($r = 0.88$) between mercury levels in chain pickerel and forage fish (same year of sampling). The coefficient of determination (r^2) is 0.77, indicating that the linear relationship between the mercury concentrations in average-sized chain pickerel and forage fish explains slightly greater than 75% of the total variation in the mercury concentrations noted each year within pickerel. The strong similarity between increasing and decreasing mercury concentrations within pickerel and forage fish is likely attributable to the fact that forage fish represent the primary prey for pickerel.

The Spearman Rank Order correlation for the Lower Reservoir concluded that no strong correlations exist between chain pickerel mercury concentrations and all of the factors included in the correlation analyses. The highest correlation ($r = 0.53$) was noted between chain pickerel and forage fish mercury concentrations.

4.2.3.3 Largemouth Bass Yearly Differences

In 2012, 2013 and 2014, average-sized largemouth bass collected from the Upper Reservoir contained significantly more mercury than bass collected and analyzed in 2004, 2005, 2006 2007 and/or 2009. The observed increase in mercury levels within largemouth bass within the Upper

Reservoir corresponds to the general trends noted between 2004 and 2014 in both zooplankton and forage fish collected from the Upper Reservoir.

For the Upper Reservoir, similar to the results for the chain pickerel discussed above, the Pearson correlation found a strong correlation (r = 0.86) between mercury levels in largemouth bass and forage fish (same year of sampling). The coefficient of determination (r^2) is 0.74, indicating that the linear relationship between the mercury concentrations in average-sized largemouth bass and forage fish explains slightly approximately 75% of the total variation in the mercury concentrations noted each year within the bass samples. The strong similarity between increasing and decreasing mercury concentrations within largemouth bass and forage fish is likely attributable to the fact that forage fish represent the primary prey for the bass.

The concentrations of mercury in largemouth bass collected in 2012 from the Lower Reservoir were significantly greater than 2005, 2007 and 2009 levels. The elevated levels noted in 2012 are likely attributable to the high concentrations of mercury detected in forage fish collected from the Lower Reservoir in 2012. However, the Spearman Rank Order correlation for the Lower Reservoir concluded that strong correlations are absent between largemouth bass mercury concentrations and all of the factors included in the correlation analyses. The highest correlation (r = 0.59) was noted between largemouth bass and forage fish mercury concentrations.

4.2.3.4 Yellow Perch Yearly Differences

Significantly higher mercury concentrations were detected in yellow perch samples collected from the Lower Reservoir in 2012 than in 2007 and 2009. The concentrations of mercury detected in the perch samples were compared to the plankton and forage fish mercury concentrations (same year and previous year to collection of yellow perch samples) and the amount of precipitation in the 4, 6, 9 and 11 months prior to collection of the perch samples to determine if there was a correlation between these factors. The Spearman Rank Order correlation analysis for the Lower Reservoir concluded that weak correlations exist between yellow perch mercury concentrations and all of the factors included in the correlation analyses. The highest correlation (r = 0.54) was noted between yellow perch and forage fish mercury concentrations. However, the correlation observed between yellow perch and forage fish is likely due to similar modes of exposure each year. The average-sized yellow perch sampled represent omnivores that primarily consume macroinvertebrates while forage fish would be expected to prey on zooplankton as well as smaller invertebrates. The weak similarity observed between increasing and decreasing mercury concentrations within yellow perch and forage fish is likely attributable to similar trends in their respective prey.

4.2.4 Tree Swallow Egg Trends and Yearly Differences

Tree swallow eggs within the Upper and Lower Reservoirs exhibited a significantly increasing trend in mercury levels ($\alpha \leq 0.05$) from 2004 to 2014. The increasing trend in egg mercury concentrations is comparable to the observed increasing trend in methylmercury and mercury levels in other biota sampled from the two reservoirs.

Significantly lower mercury concentrations were detected in tree swallow eggs collected in 2004 and 2008 within the Upper Reservoir compared to levels detected in eggs collected from this water body in 2009, 2012, 2013 and 2014. In addition, the elevated concentrations of mercury detected in the Upper Reservoir eggs in 2013 and 2014 are significantly greater than levels detected in 2005 and 2006. Mercury levels detected in Lower Reservoir eggs in 2013 are significantly higher than concentrations noted in 2004.

The concentrations of mercury detected in tree swallow egg samples were compared to the plankton methylmercury concentrations (same year and previous year to collection of tree swallow eggs) and amount of precipitation in the 4, 6, 9 and 11 months prior to collection of the eggs to determine if there was a correlation between these factors. The number of comparable samples available for the Upper Reservoir exceeds 50 which would minimize bias in non-normally distributed data. However, less than 50 comparable data sets are available for tree swallow eggs within the Lower Reservoir and the Lower Reservoir mercury results were not normally distributed. Therefore, the Pearson correlation was used for the Upper Reservoir analyses while the nonparametric Spearman Rank Order correlation was used for the Lower Reservoir data.

For the Upper Reservoir, there was a fairly strong correlation ($r = 0.68$) noted for mercury concentrations in eggs and plankton methylmercury levels. The elevated concentrations noted in the Upper Reservoir tree swallow eggs in 2009, 2012 and 2013 generally correspond to the concentrations of methylmercury noted in zooplankton sampled from the Upper Reservoir as the highest concentrations of methylmercury in zooplankton were observed during 2009, 2012 and 2013 when tree swallow eggs were also collected. Elevated levels of mercury within zooplankton are likely to be correlated with high concentrations of mercury within aquatic insects which comprise important prey for tree swallows. As nesting tree swallows forage on emerging aquatic insects, mercury levels in tree swallow eggs would be expected to increase as the levels in their forage base increases. However, aquatic insects within the Upper Reservoir are not included in the biomonitoring program.

Mercury concentrations in tree swallow eggs collected from the Lower Reservoir were not strongly correlated with any of the factors evaluated. The strongest correlation noted was with the amount of precipitation noted in the preceding 11 months prior to egg collection (r = 0.55). It is unclear what factor(s) may be involved in the differing levels of mercury noted in the eggs collected from the Lower Reservoir. Although relatively few tree swallow eggs were collected each year from the Lower Reservoir (e.g., four eggs sampled in 2013), it is not expected that the elevated mercury concentrations noted in 2013 would be associated with egg variability within each clutch as a previous study reported that tree swallow egg concentrations at a mercury-contaminated site did not decline with laying sequence (Brasso et al., 2010).

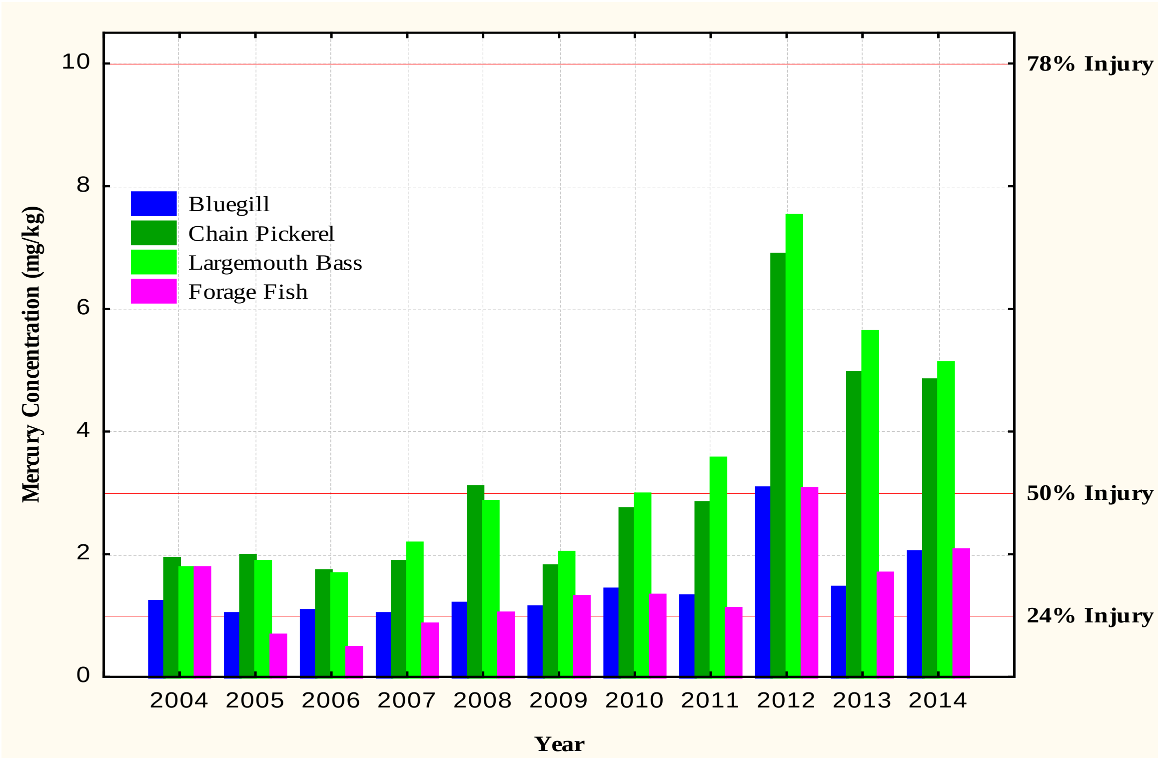
4.3 Ecological Risks

4.3.1 Fish

Risks to fishes inhabiting the Upper and Lower Reservoirs were evaluated by comparing the median fish concentrations of mercury detected for each year of the sampling with adverse effect levels reported in the literature. Dillon et al. (2010) reviewed published papers reporting mercury fish tissue concentrations with adverse effect endpoints which were dose-responsive and could be related to lethality. Actual endpoints included direct mortality, severe developmental abnormalities as well as spawning failure by adult fish and were used to derive a percent (%) injury. Paired observations of mercury tissue concentrations in juvenile or adult fish (based on dietary or surface water exposure) with percent injury were used to prepare a dose-response curve (Dillon et al., 2010). Based on this curve, an effect concentration of 50% injury was calculated to be 3.0 mg/kg of mercury in fish whole-body tissue while concentrations of 1.0 and 10.0 mg/kg mercury represented a 24% and 78% injury, respectively (Dillon et al., 2010). These effect concentrations were compared to median fish tissue concentrations of fish sampled from the SBAC and the Upper and Lower Reservoirs. It should be noted that more subtle effects on fish, such as changes in behavior that may result in lower survival could occur at lower mercury whole-body burden concentrations that these effect concentrations. In addition, of the 10 study treatments that reported 100% injury to juvenile and adult fish, the median whole-body mercury concentration was 8.3 mg/kg (Dillon et al., 2010).

Upper Reservoir: The median concentrations of mercury within forage fish, bluegills, chain pickerel and largemouth bass collected from the Upper Reservoir during 2004 through 2014 are presented in Figure 4-2. Median mercury concentrations within bluegills and forage fish (often comprised of young bluegills) are similar and typically near the 24% injury factor except in 2012 when median concentrations were at the 50% injury factor. As the median concentrations of both bluegills and forage fish exceed the 24% injury factor over the past six years, it is possible that the population of bluegills within the Upper Reservoir is being affected by the mercury concentrations present in this aquatic habitat.

Figure 4-2.
Comparison of Median Mercury Concentrations in Upper Reservoir Fish with Injury Factors, 2004 - 2014



Median concentrations of mercury within chain pickerel and largemouth bass for six of the past seven years are approximately at or exceed the concentration associated with a 50% injury factor. Median concentrations of mercury within both species in 2012 approached the median concentration of 8.3 mg/kg associated with 100% injury (Dillon et al., 2010). The mercury tissue concentration of 1.0 mg/kg associated with a 24% injury factor was exceeded in all years of the biomonitoring. Overall, the median mercury concentrations detected in chain pickerel and largemouth bass suggest that adverse impacts are possible to the populations of these two species. It is interesting to note that the numbers of largemouth bass noted during the 2014 sampling event within the Upper Reservoir declined approximately 40% from numbers observed in the preceding years (Table 4-4). It is unknown if this decrease may be associated with consistently elevated mercury concentrations within largemouth bass or other environmental factors such as the reported fish kill associated with a severe storm event that occurred at the FAA Technical Center in July 2014.

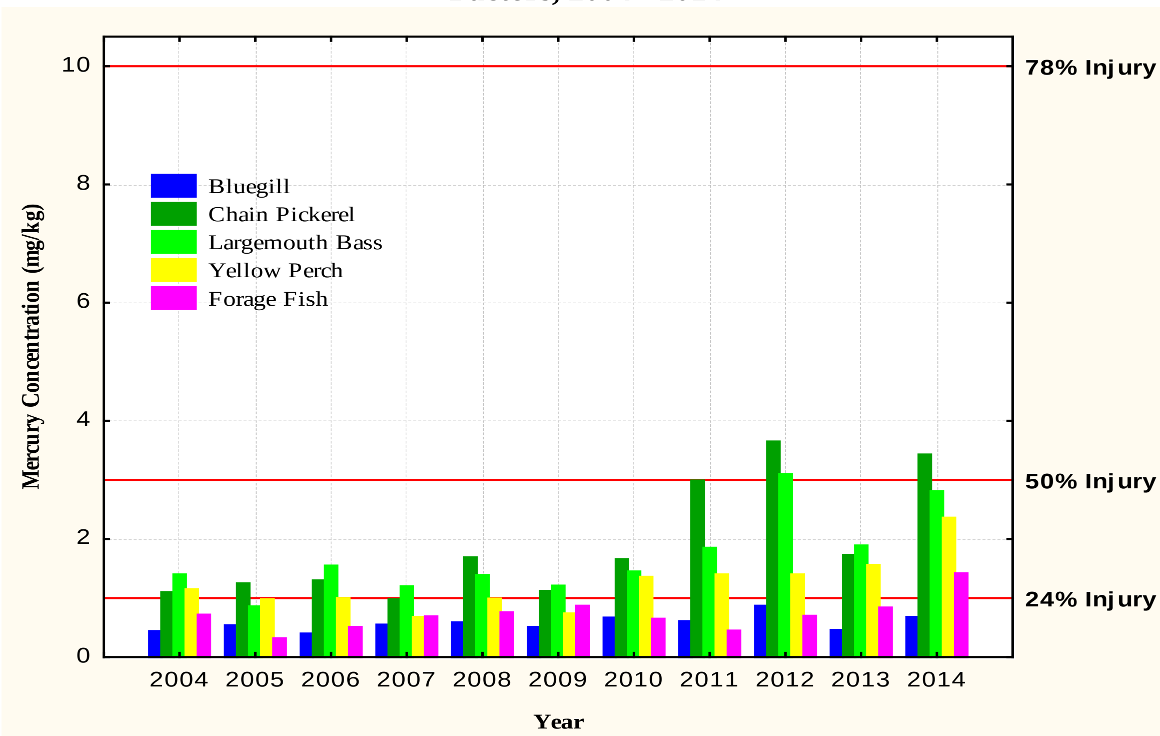
Lower Reservoir: Figure 4-3 presents a comparison of the median concentrations of mercury detected in bluegills, chain pickerel, largemouth bass, yellow perch and forage fish sampled from the Lower Reservoir with the injury factors derived from Dillon et al. (2010).

Table 4-4.
Fish Capture Numbers at Upper and Lower Reservoirs, 2004 - 2014.

Reservoir/	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014	
Species/Size	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Upper Reservoir																						
Bluegill																						
<150mm	104	5%	1	1%	3	1%	4	2%	0	0%	1	0%	1	0%	2	1%	6	2%	7	2%	7	3%
150 - 200mm	424	20%	8	7%	10	4%	36	14%	7	4%	25	12%	2	1%	13	6%	31	10%	96	25%	90	33%
>200mm	657	31%	56	50%	111	45%	75	28%	41	21%	58	27%	69	33%	88	37%	80	27%	62	16%	44	16%
Chain Pickerel																						
<350mm	38	2%	6	5%	4	2%	5	2%	2	1%	12	6%	10	5%	6	3%	13	4%	28	7%	16	6%
350-450mm	58	3%	9	8%	7	3%	18	7%	18	9%	12	6%	25	12%	21	9%	32	11%	36	9%	48	18%
>450mm	31	1%	3	3%	2	1%	5	2%	8	4%	3	1%	6	3%	2	1%	9	3%	8	2%	6	2%
Largemouth Bass																						
<300mm	234	11%	18	16%	31	13%	58	22%	43	22%	25	12%	27	13%	19	8%	61	21%	34	9%	8	3%
300-400mm	575	27%	6	5%	65	26%	46	17%	57	29%	67	31%	63	30%	74	31%	52	18%	86	22%	45	16%
>400mm	22	1%	0	0%	7	3%	10	4%	17	9%	10	5%	3	1%	5	2%	8	3%	24	6%	3	1%
Total	2143		111		247		264		194		213		209		236		297		383		274	
Lower Reservoir																						
Bluegill																						
<150mm	569	17%	4	2%	18	8%	8	5%	1	1%	1	1%	4	2%	0	0%	2	1%	6	2%	8	3%
150 - 200mm	936	27%	39	19%	39	17%	27	18%	15	10%	13	10%	20	10%	36	16%	42	16%	78	25%	77	30%
>200mm	221	6%	21	10%	30	13%	9	6%	23	15%	21	17%	16	8%	52	23%	37	14%	44	14%	46	18%
Chain Pickerel																						
<350mm	221	6%	14	7%	9	4%	9	6%	4	3%	7	6%	25	12%	9	4%	7	3%	24	8%	18	7%
350-450mm	192	6%	30	15%	14	6%	8	5%	16	10%	9	7%	18	9%	24	11%	30	11%	29	9%	23	9%
>450mm	46	1%	7	3%	11	5%	4	3%	8	5%	4	3%	2	1%	6	3%	4	2%	9	3%	5	2%
Largemouth Bass																						
<300mm	130	4%	18	9%	13	6%	13	8%	9	6%	6	5%	15	7%	10	4%	12	5%	10	3%	7	3%
300-400mm	387	11%	22	11%	42	18%	26	17%	25	16%	28	22%	45	22%	33	15%	46	17%	54	17%	19	7%
>400mm	62	2%	6	3%	7	3%	4	3%	10	6%	4	3%	7	3%	2	1%	6	2%	12	4%	2	1%
Yellow Perch																						
≤200mm	281	8%	18	9%	17	7%	18	12%	9	6%	4	3%	13	6%	10	4%	9	3%	11	4%	13	5%
>200mm	403	12%	10	5%	31	13%	15	10%	31	20%	27	22%	37	18%	37	17%	61	23%	28	9%	21	8%
Total	3448		201		235		154		154		125		204		224		264		313		258	

Note: # refers to the number of fish captured for that size class for each species.

Figure 4-3.
Comparison of Median Mercury Concentrations in Lower Reservoir Fish with Injury Factors, 2004 - 2014



The median concentrations of mercury detected in bluegills are below the 24% injury factor concentration in all 11 years of the biomonitoring study indicating that significant adverse effects to the bluegill population are unlikely. Median forage fish concentrations exceed the 24% injury factor in 2014 only. The median mercury concentrations within yellow perch during all years of the biomonitoring are approximately equal to the 24% injury factor concentration. However, for the past five years, the median yellow perch mercury concentrations exceed this factor (and approach the 50% injury factor in 2014) indicating that this species may be adversely affected by mercury.

Median concentrations of mercury in chain pickerel and largemouth bass exceed the concentration associated with a 24% injury factor while median concentrations of one or both of these species exceed the 50% injury factor concentration in 2011, 2012 and 2014. The median concentrations of mercury detected in large chain pickerel and largemouth bass in 2002 and 2013 (but not 2009) exceed the 50% injury factor. Overall, the detected concentrations of mercury within chain pickerel and largemouth bass indicate that these species may be adversely affected by mercury levels present within the Lower Reservoir. Although the number of largemouth bass captured in 2014 decreased substantially compared to the preceding years, the decrease was approximately 20% or only one-half of the decrease noted in the Upper Reservoir fish community.

4.3.2 Aerial Insectivorous Species

Risks to aerial insectivorous species (i.e., tree swallow and northern long-eared bat) were evaluated by comparing mercury concentrations within their eggs or hair to their respective egg/hair toxicity reference values. Results are discussed below for each species.

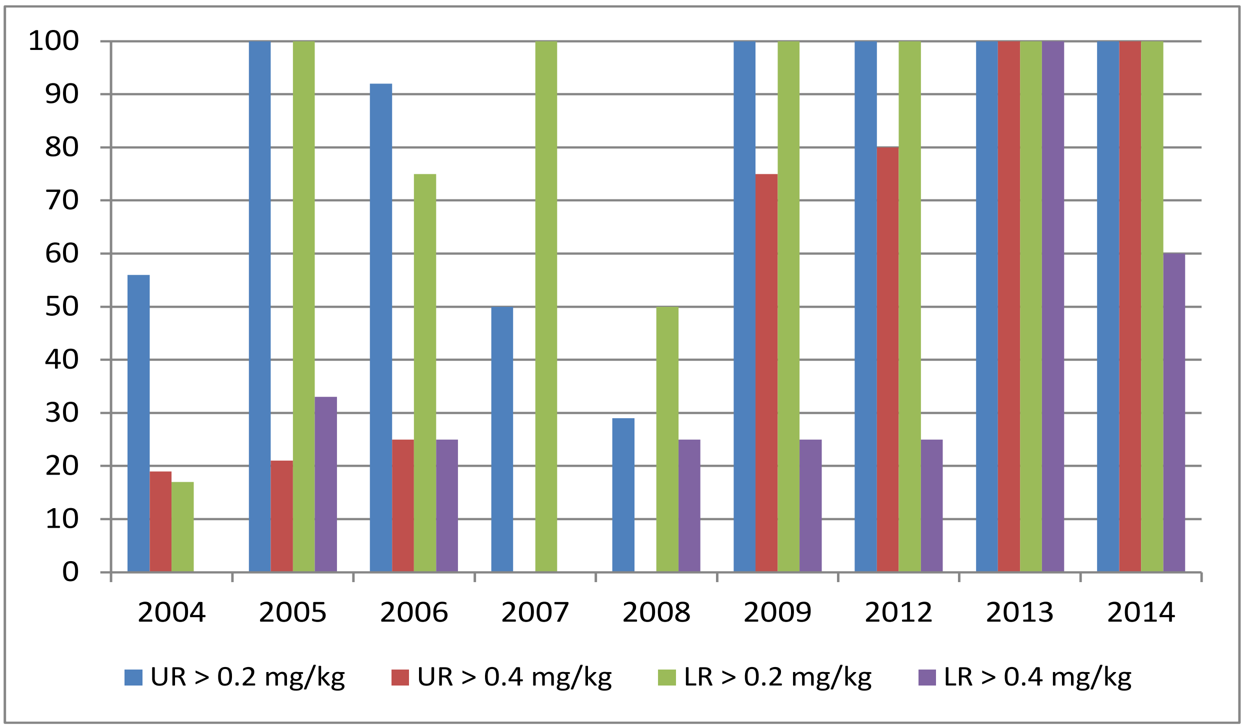
Tree Swallow: The maximum tree swallow egg concentration of mercury at the Upper Reservoir ranged from 0.22 mg/kg to 0.51 mg/kg during 2004 through 2008 and increased to 1.73 and 1.22 mg/kg in 2009 and 2012, respectively. Maximum concentrations of mercury increased to 3.24 and 2.05 mg/kg in 2013 and 2014, respectively. Mercury concentrations within tree swallow eggs collected from the Lower Reservoir are somewhat lower although the maximum detected mercury concentration was 2.09 mg/kg in 2013.

Concentrations of mercury within avian eggs that are associated with adverse effects on birds vary with the species being evaluated. Heintz et al. (2009) injected methylmercury into avian embryos for over 20 species in order to determine embryonic thresholds. Tree swallows were found to have medium sensitivity to methylmercury egg injection among the species tested. Based on these results, a mercury egg concentration of 0.1 mg/kg resulted in a 29 percent reduction in embryo survival (Jackson, 2011). Although Heintz et al. (2009) noted that injected methylmercury is approximately two to four times as embryotoxic as maternally transferred methylmercury, recent, unpublished findings suggest that injected methylmercury may actually be more similar to maternally transferred mercury (Jackson, 2011). Based on this, Jackson (2011) proposed multiplying the injected methylmercury effect concentration by a factor of two to equate to a maternally transferred methylmercury egg concentration. Thus, 0.2 mg/kg (wet weight) of mercury represents a tree swallow egg concentration that may be associated with adverse effects on tree swallow reproduction (Jackson, 2011).

Egg mercury concentrations resulting in adverse effects on avian reproduction of other species have been reported for the common loon (1.30 mg/kg), mallard (0.80 mg/kg), common grackle (0.40 mg/kg) and ring-necked pheasant (0.20 mg/kg) (Evers et al., 2007). The common grackle and ring-necked pheasant were found to be similar to the tree swallow in that all three species were found to have medium sensitivity to methylmercury egg injection (Heintz et al., 2009). The 0.2 mg/kg mercury concentration proposed by Jackson (2011) is likely to represent a conservative, but realistic threshold, as this value coincides with the ring-necked pheasant threshold concentration. The 0.4 mg/kg mercury concentration associated with adverse effects to the common grackle would represent a less conservative threshold value as this value equates to the tree swallow methylmercury injection effect concentration multiplied by a factor of four as originally proposed in Heintz et al. (2009).

An evaluation of the mercury concentrations detected within each tree swallow egg collected at the Upper and Lower Reservoirs was conducted by comparing the yearly results to the proposed tree swallow threshold egg mercury concentrations of 0.2 mg/kg and 0.4 mg/kg. This comparison is depicted in Figure 4-4.

Figure 4-4.
Percent of Tree Swallow Eggs within Upper and Lower Reservoirs Exceeding Mercury Toxicity Thresholds, 2004-2009 and 2012-2014



Over the entire biomonitoring period of 2004 through 2009 and 2012 through 2014, approximately 80% of the tree swallow eggs collected at the Upper Reservoir detected mercury at concentrations greater than the 0.2 mg/kg egg toxicity threshold. Nearly 50% of these eggs have mercury concentrations above the 0.4 mg/kg egg toxicity threshold. However, over the last three biomonitoring sampling years (2012 through 2014) over 95% of the sampled tree swallow eggs exceed the 0.4 mg/kg threshold.

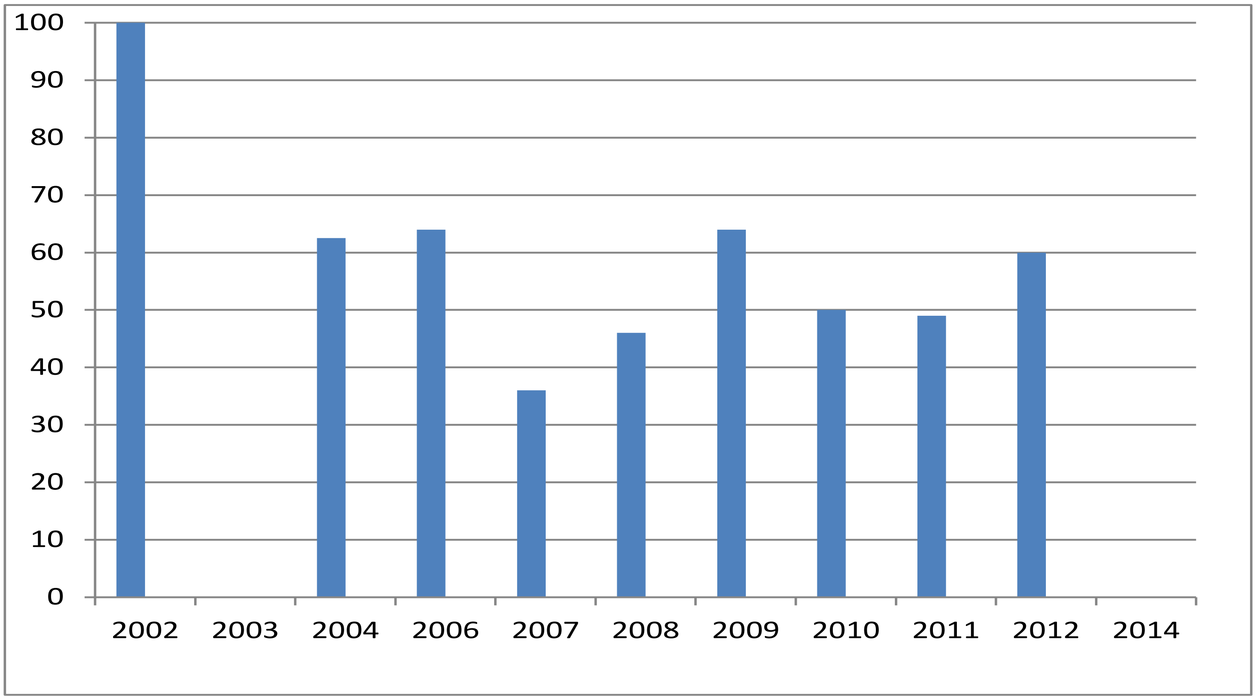
Concentrations of mercury detected in tree swallow eggs collected from the Lower Reservoir are generally lower than observed at the Upper Reservoir. Approximately 80% and 33%, respectively, of the eggs collected from the Lower Reservoir during the entire biomonitoring period detected mercury at concentrations greater than the 0.2 and 0.4 mg/kg egg toxicity thresholds. Although concentrations of mercury in eggs collected from the Lower Reservoir are lower than noted at the Upper Reservoir, tree swallow reproduction may potentially be adversely affected by the elevated mercury levels detected in the eggs at the Lower Reservoir as egg concentrations of mercury generally are elevated above the lower threshold value of 0.2 mg/kg.

In 2013, the mean concentrations of mercury detected in tree swallow eggs collected from both the Upper and Lower Reservoirs were over two times higher than detected in any of the preceding seven years of biomonitoring. Approximately 75% or greater of the eggs collected from each reservoir contained greater than 1 mg/kg mercury. In addition, 40% and 25% of the eggs collected from the Upper and Lower Reservoirs, respectively, contained greater than 2 mg/kg mercury. These elevated concentrations are likely to result in reproductive impacts to tree swallows breeding at the reservoirs. Many of the eggs that contained the highest mercury concentrations were collected from nest boxes that either contained only one lone egg or four/five nestlings with one egg also present. It is possible that the high mercury concentrations within these eggs caused the eggs to not hatch. Although levels of mercury in tree swallow eggs declined substantially in 2014 within the Lower Reservoir, the mercury concentrations detected in eggs collected from the Upper Reservoir in 2014 declined slightly but remain elevated compared to earlier sampling events.

Northern Long-Eared Bat: The mean and maximum northern long-eared bat hair concentrations of mercury from samples collected within Area U from 2006 through 2012 and in 2014 were presented in Table 3-8. During this timeframe, the mean mercury hair concentrations detected within Area U varied substantially ranging from 3.8 mg/kg in 2003 to 33.4 mg/kg in 2012. The overall mean northern long-eared bat hair mercury concentration during the entire sampling period is 27.0 mg/kg. A recent study that sampled 148 northern long-eared bat hair samples throughout the northeast during 2006 through 2008 reported a mean mercury concentration of approximately 8.0 mg/kg (Osborne et al., 2011). Regional differences were noted in northern long-eared bat hair mercury levels with samples collected from Central/Western New York exhibiting the highest mean concentration of 16.9 mg/kg (Osborne et al., 2011).

A recent study of mercury effects on the closely related little brown bat indicates a bat hair concentration of 10 mg/kg represents a preliminary subclinical threshold. Little brown bats with hair concentrations above this threshold were found to have changes in their neurochemistry (Nam et al., 2012). An evaluation of the mercury concentrations detected within each northern long-eared bat hair sample collected within Area U was conducted by comparing the yearly results to the bat hair threshold mercury concentration of 10 mg/kg (Figure 4-5).

Figure 4-5.
Percent of Northern Long-Haired Bat Hair Samples Exceeding Mercury Toxicity Threshold, 2006 – 2012 and 2014



Over the biomonitoring period of 2006 through 2012 and 2014, approximately 50% of the northern long-eared bat hair samples collected within Area U detected mercury at concentrations greater than the 10 mg/kg bat hair threshold. It should also be noted that almost all of the bats that were recaptured had higher mercury concentrations present in their hair than the levels noted during their initial capture. Ten of the 11 northern long-eared bats had mercury concentrations above the hair threshold at the time of their recapture (the one bat that did not had an non-detect result at a 14 mg/kg detection limit) while only 4 of these 11 bats exceeded the hair threshold at the time of initial capture (see Table 3-9). Therefore, northern long-eared bats foraging within Area U are exposed to mercury and may potentially be adversely affected by mercury as a substantial percentage of the bat population have elevated mercury levels above a threshold level associated with neurological effects, particularly as they get older and are repeatedly exposed to mercury.

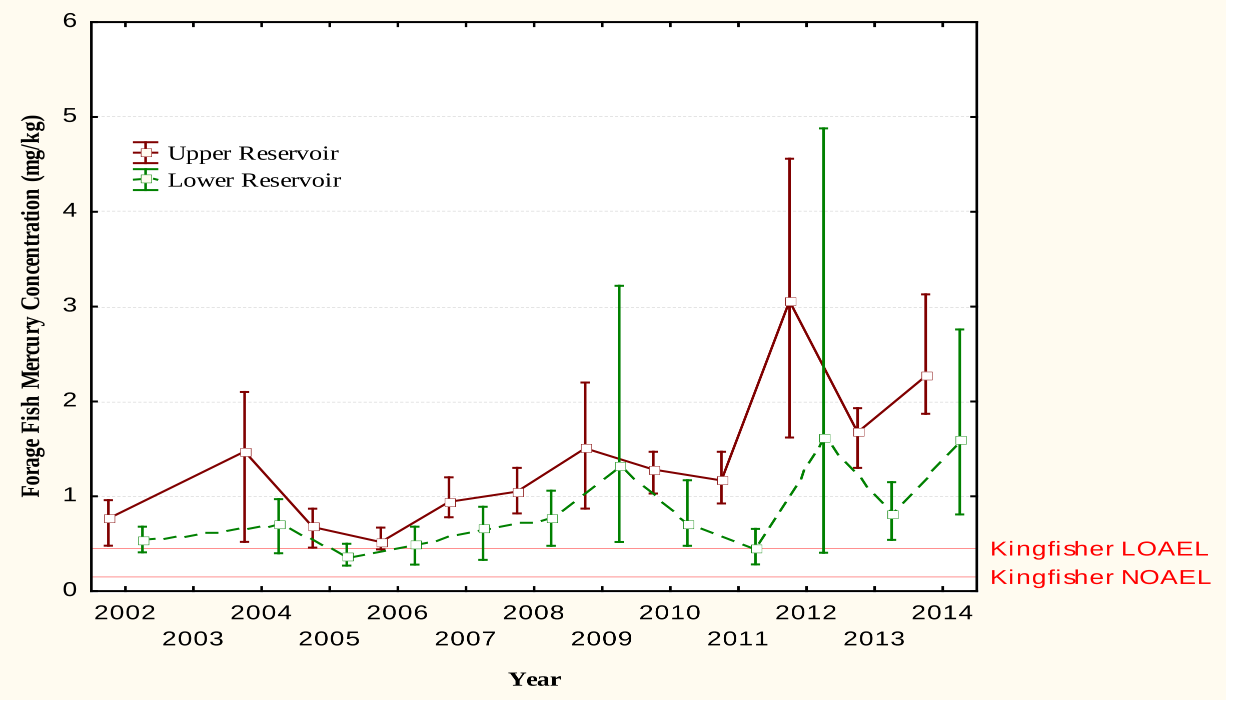
4.3.3 Piscivorous Species

Risks to piscivorous birds and mammals that forage on fish at the Upper and Lower Reservoirs were evaluated using the biomonitoring data and comparing fish tissue concentrations to tissue concentrations corresponding to piscivore No Observable Adverse Effect Level (NOAEL) and

Lowest Observable Adverse Effect Level (LOAEL) toxicity reference values (TRVs). Results are discussed below for each piscivorous species evaluated.

Belted Kingfisher: Based on exposure parameters presented in TRC (2010), fish tissue mercury concentrations associated with exposure doses equal to the NOAEL and LOAEL TRVs for the kingfisher are 0.15 mg/kg and 0.45 mg/kg (wet weight), respectively. A comparison of these fish tissue TRVs with mercury concentrations within forage fish collected from the Upper and Lower Reservoirs during the biomonitoring study is presented in Figure 4-6.

Figure 4-6.
Belted Kingfisher Risks from Mercury within Forage Fish within Upper and Lower Reservoirs, 2002-2014



As shown in Figure 4-6, risks to the belted kingfisher from ingestion of forage fish (mean concentration) at the Upper Reservoir has consistently been above the kingfisher mercury LOAEL TRV. The mean forage fish mercury concentration detected at the Upper Reservoir for several years (2004, 2009, 2012 and 2013) are greater than three times the kingfisher LOAEL.

Mercury concentrations at the Lower Reservoir are consistently above the kingfisher NOAEL TRV and typically are elevated above the LOAEL TRV except during 2005 and 2011 when mean concentrations were slightly below the LOAEL TRV. Overall, the mean forage fish concentrations of mercury exceed the kingfisher LOAEL TRV during all 12 years that forage fish were collected at the Upper Reservoir. At the Lower Reservoir, risk to kingfishers from the ingestion of forage fish generally has increased since 2005 until 2011 when the mean forage fish mercury concentration was slightly below the kingfisher LOAEL TRV. However, risks increased in 2012 to the highest levels noted since samples were collected at this waterbody before declining in 2013 and then increasing again in 2014.

Kingfisher risk from foraging on small fish at both reservoirs combined (it is assumed that a kingfisher forages 50 percent of the time at each reservoir based on the piscivore foraging study) suggest even further that reproductive impacts to kingfishers potentially are present although it is unknown whether kingfishers are more or less sensitive to mercury than the mallard duck, the species for which the LOAEL was determined. Acute adverse effects such as direct mortality of kingfishers from ingesting fish containing elevated concentrations of mercury are not anticipated.

For comparison purposes, the mean background concentration of mercury for forage fish samples collected within the Pinelands (USFWS, 1998; Horwitz et al., 1999) is 0.18 which is slightly above the belted kingfisher NOAEL TRV but well below the fish tissue mercury LOAEL TRV for the kingfisher.

Osprey: Fish tissue mercury concentrations associated with exposure doses equal to the NOAEL and LOAEL TRVs for the osprey are 0.87 mg/kg and 2.66 mg/kg (wet weight), respectively, for the Upper Reservoir. Fish tissue NOAEL and LOAEL TRVs for the osprey at the Lower Reservoir are slightly lower at 0.58 mg/kg and 1.77 mg/kg, respectively, due to a greater foraging frequency at the Lower Reservoir as determined from piscivore use studies of both reservoirs (TRC, 2010). A comparison of these fish tissue TRVs with mercury concentrations within average-size bluegills, chain pickerel, largemouth bass and yellow perch collected from the Upper and/or Lower Reservoirs during the biomonitoring study is presented in Figures 4-7 and 4-8, respectively.

Risks to the osprey from ingestion of bluegills (mean concentration) at the Upper Reservoir have consistently been above the osprey mercury NOAEL TRV but are well below the LOAEL TRV (except in 2012 when the mean bluegill mercury level slightly exceeded the LOAEL TRV) while mean average-size chain pickerel and largemouth bass mercury concentrations at the Upper Reservoir are elevated above the osprey NOAEL TRV and exceed the LOAEL TRV during some years of the biomonitoring. The mean concentrations of mercury detected in pickerel and/or bass in 2008, 2010, 2011, and particularly in 2012 through 2014 are elevated above the LOAEL fish tissue TRV (Figure 4-7).

Mean bluegill mercury concentrations at the Lower Reservoir are approximately equal to the osprey fish tissue NOAEL TRV (Figure 4-8). Yellow perch collected from the Lower Reservoir

Figure 4-7.
Osprey Risks from Mercury within Average-Size Fish at Upper Reservoir, 2002-2014

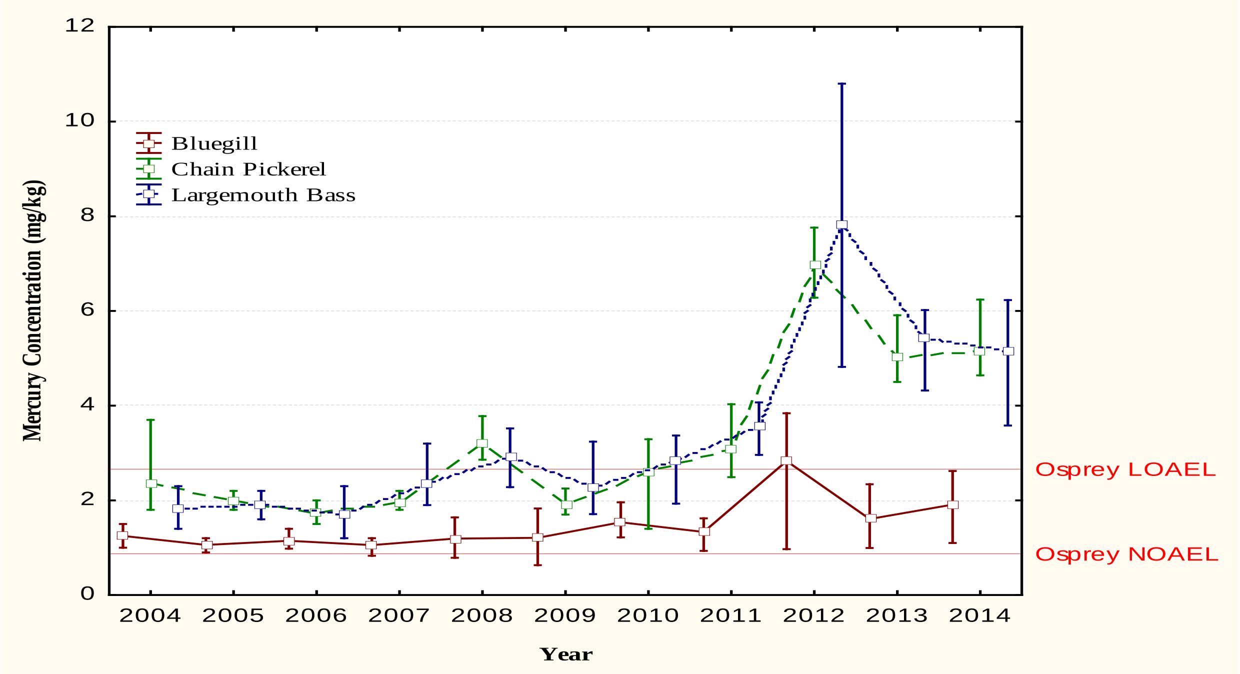
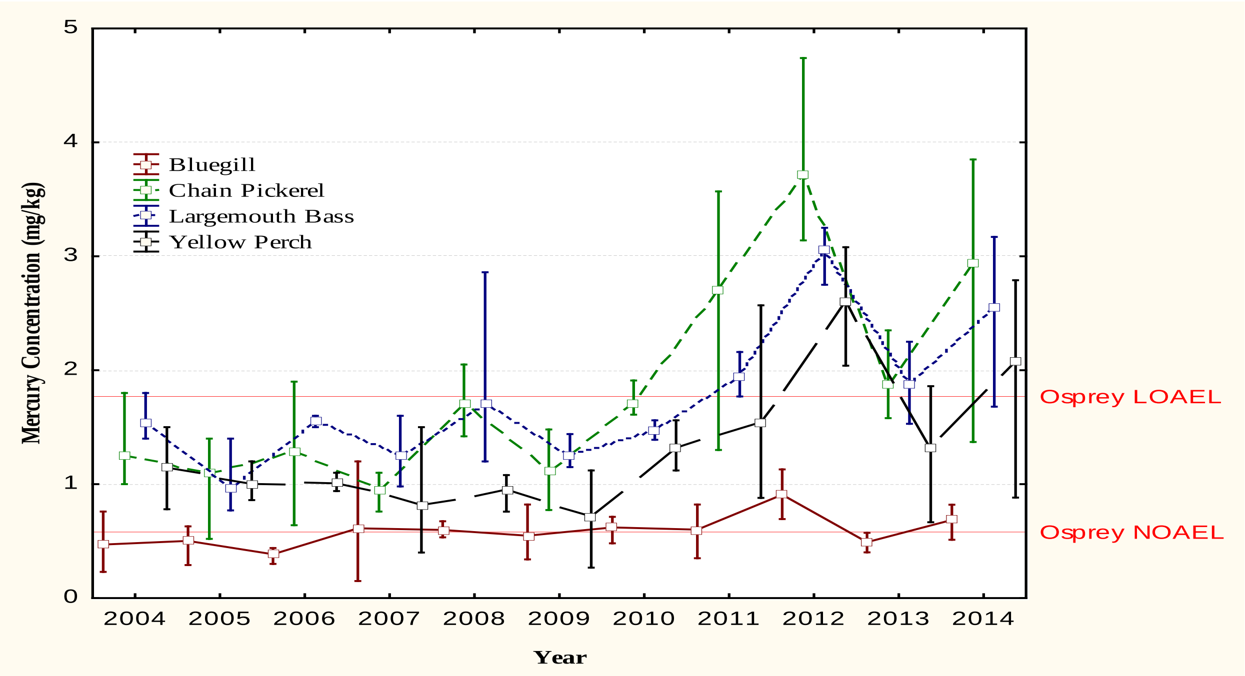


Figure 4-8.
Osprey Risks from Mercury within Average-Size Fish at Lower Reservoir, 2002-2014



have mean mercury concentrations that exceed the fish tissue NOAEL TRV but are less than the LOAEL TRV except during 2012 and 2014 when yellow perch mercury concentrations exceeded the osprey LOAEL fish tissue TRV.

Mean concentrations of mercury within average-size chain pickerel and largemouth bass from the Lower Reservoir are generally elevated above the osprey NOAEL TRV but less than the LOAEL TRV. However, the mean concentrations of mercury detected in pickerel and bass in the Lower Reservoir in 2011 through 2014 are elevated above the LOAEL fish tissue TRV.

For comparison purposes, background concentrations of mercury in predatory fish (0.59 mg/kg) sampled from aquatic habitats within the Pinelands (USFWS, 1998; Horwitz et al., 1999) would be approximately equal to the Lower Reservoir NOAEL fish tissue TRV but are below the Upper Reservoir NOAEL TRV and LOAEL TRVs for both reservoirs.

The fish tissue LOAEL TRVs presented for the osprey in Figures 4-7 and 4-8 are based on an osprey foraging within either the Upper or Lower Reservoir. However, if foraging effort for both reservoirs is combined, the associated mercury fish tissue LOAEL TRV for the osprey would be reduced to 1.06 mg/kg. This LOAEL TRV is exceeded by mean concentrations of mercury within chain pickerel and largemouth bass at both reservoirs as well as by the mean concentrations of mercury within Upper Reservoir bluegills. Recent (i.e., 2010 through 2014) mean concentrations of mercury in yellow perch sampled from the Lower Reservoir also exceed this combined reservoir LOAEL fish tissue TRV.

Overall, ospreys may potentially be at risk of having reproductive impacts from foraging on fish within the Upper Reservoir and from foraging on predator fish (chain pickerel and largemouth bass) present within the Lower Reservoir. This risk is of concern particularly for the osprey as this species is more sensitive to mercury than the mallard duck, the species for which the LOAEL fish tissue TRV was determined (Heintz et al., 2009).

Mink: Based on exposure parameters presented in TRC (2010), fish tissue mercury concentrations associated with exposure doses equal to the NOAEL and LOAEL TRVs for the mink are 0.41 mg/kg and 0.65 mg/kg (wet weight), respectively. The mink NOAEL and LOAEL TRVs are based on chronic toxicity studies conducted with mink (Wren et al., 1987 and Chamberland et al., 1996). A comparison of these fish tissue TRVs with mercury concentrations within average-size fish collected from the Upper and Lower Reservoirs during the biomonitoring study are presented in Figures 4-9 and 4-10.

The mean mercury concentration detected in bluegills, chain pickerel and largemouth bass at the Upper Reservoir throughout the biomonitoring period are greater than the mink LOAEL fish

Figure 4-9.
Mink Risks from Mercury within Average-Size Fish at Upper Reservoir, 2002-2014

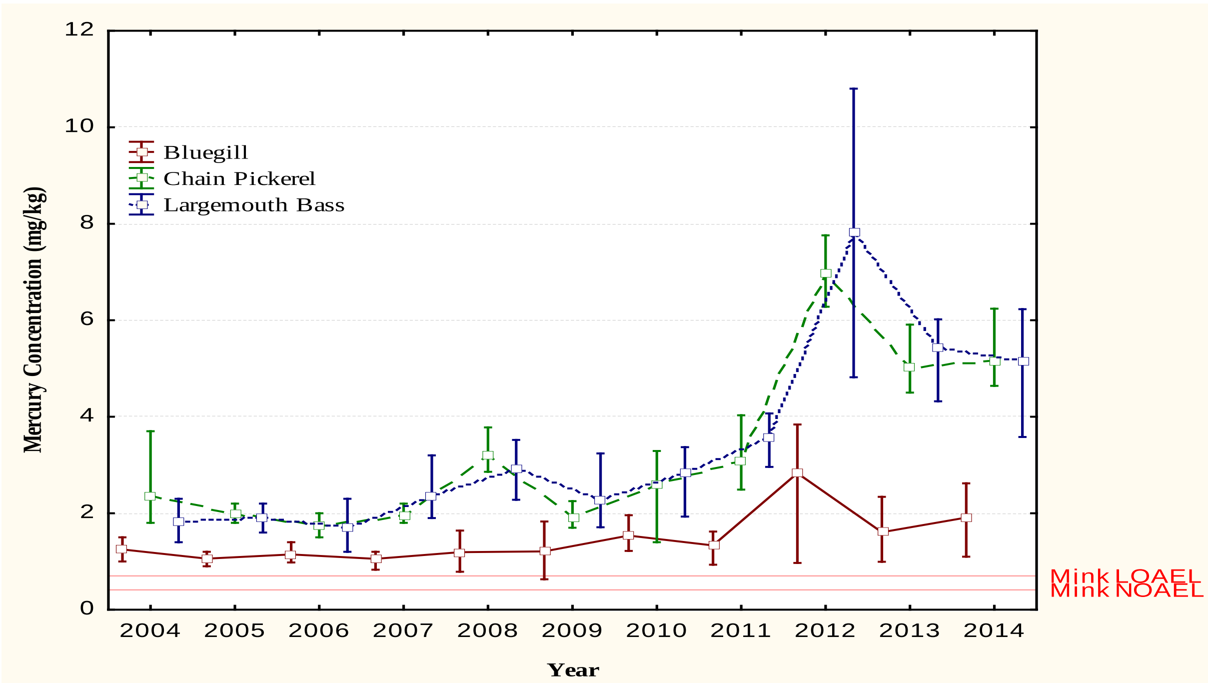
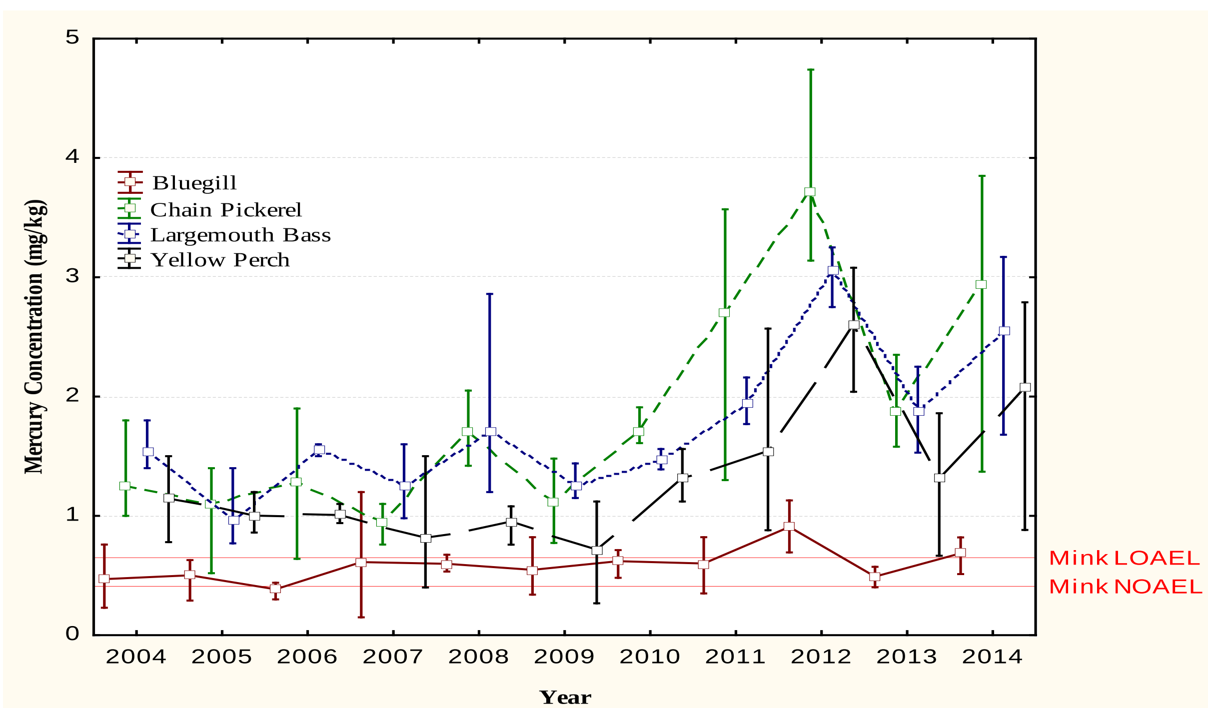


Figure 4-10.
Mink Risks from Mercury within Average-Size Fish at Lower Reservoir, 2002-2014



tissue TRV. Mercury concentrations within chain pickerel and largemouth bass are approximately three times the mink LOAEL TRV except during 2012 when mean mercury concentrations are approximately ten times the fish tissue LOAEL TRV for mink.

Mercury concentrations within chain pickerel, largemouth bass and yellow perch sampled at the Lower Reservoir are also consistently above the mink LOAEL TRV with pickerel and bass mercury tissue concentrations typically elevated two times the LOAEL TRV although recent 2011 and 2012 sampling results indicate the LOAEL is exceeded by a factor of four or greater. Mean mercury concentrations within bluegills sampled within the Lower Reservoir exceed the mink NOAEL TRV but are generally below the mink LOAEL TRV.

For comparison purposes, background concentrations of mercury in predatory fish (0.59 mg/kg) sampled from aquatic habitats within the Pinelands (USFWS, 1998; Horwitz et al., 1999) would be greater than the mink NOAEL fish tissue TRV but are less than the LOAEL TRV. Exceeding the LOAEL HQ is considered significant for the mink as the LOAEL is based on actual mink neurotoxicity and mortality (Chamberland et al., 1996). Although the Pinelands background predator fish tissue concentration approaches the mink LOAEL fish tissue TRV, it is still less than the mink LOAEL associated with observed mink mortality. Fish tissue concentrations of mercury detected at both the Upper and Lower Reservoirs strongly suggest that mercury-related impacts to mink may result from consuming average-sized fish from these reservoirs.

5.0 CONCLUSIONS/RECOMMENDATIONS

Mercury and/or methylmercury concentrations were analyzed within selected biota collected within Area U during 2005 through 2014 for the Area U Biomonitoring Study. The concentrations detected each year were compared against one another to ascertain if differences are present in mercury/methylmercury concentrations. In addition, applicable data available from earlier studies conducted in 2002 or 2004 (TRC 2004; TRC 2010) were also compared to the biomonitoring data collected from 2005 to 2014. Eleven years of consecutive and comparable data are available for zooplankton, forage fish (in addition to data available from 2002), and average-size fish collected from the Upper and Lower Reservoirs. Nine years of data are available for tree swallow eggs within the two reservoirs. Eleven years of northern long-eared bat fur sampling data are also available.

5.1 Conclusions

Based on the analytical results of all mercury tissue data collected to date (i.e., 2002 through 2014), significantly increasing trends in methylmercury and/or mercury concentrations were noted in zooplankton, forage fish, tree swallow eggs, and average-sized bluegills, chain pickerel, and largemouth bass collected from both the Upper and Lower Reservoirs. In addition, a statistically significant increasing trend was noted in yellow perch collected from the Lower Reservoir. The two principle sources of mercury to Area U are ground water discharge associated with seeps present within the upper SBAC and areas of sediment with elevated concentrations of mercury within both the SBAC and Upper Reservoir.

The significantly increasing trend noted in the concentration of methylmercury/mercury within zooplankton, forage fish and average-size bluegill, chain pickerel, largemouth bass and yellow perch samples collected from the Upper and/or Lower Reservoirs is likely attributable to the lowering of surface water levels within the Upper Reservoir beginning in fall 2004 until 2011 when dam repairs were completed at the Upper Reservoir. The drawdown may have affected methylmercury concentrations within the surface water of the reservoirs through several different methods. First, the smaller volume of surface water within the Upper Reservoir during 2005 – 2010 may have resulted in greater concentrations of methylmercury being present within this waterbody assuming a constant methylmercury source input (e.g., groundwater discharges to the SBAC). Based on the bioaccumulation factors calculated previously for zooplankton in the Upper and Lower Reservoirs (370,000 and 420,000, respectively in TRC, 2010), even a small increase in surface water methylmercury concentrations can result in a substantial increase in the tissues of aquatic biota inhabiting these reservoirs.

Alternatively, the large area of exposed sediment within the Upper Reservoir consisting of mercury-contaminated peat would be subject to decomposition and subsequent release of organic matter and mercury (Morrison and Therien, 1994) during rainfall events when precipitation drains from these areas to the adjacent areas of the reservoir containing surface waters. A combination of both means may also be responsible for the observed increasing trends in the reservoirs. Since surface water within the Upper Reservoir discharges to the Lower Reservoir, an increase in methylmercury concentrations in surface water and zooplankton of the Lower Reservoir would also be anticipated.

In 2009, the very high amount of precipitation received in the study area resulted in an increase in surface water levels within the Upper Reservoir and some re-flooding of previously exposed sediments. This may have resulted in the production of additional methylmercury that was subsequently released to the overlying surface water and then released to the Lower Reservoir and the tidal portion of Absecon Creek below the Lower Reservoir dam.

Water levels within the Upper Reservoir were raised substantially in fall 2011 after the completion of the dam repairs and have remained at this level through 2014. The increase in the Upper Reservoir surface water level in 2011 resulted in re-inundation of formerly exposed sediment. These areas of exposed sediments included the western portion of the Upper Reservoir where the highest concentrations of mercury in sediment are present. The inundation of these areas likely facilitated the production of methylmercury which would subsequently be released to the overlying surface water. Zooplankton methylmercury concentrations in fall 2011 increased substantially in both reservoirs from their 2010 concentrations in response to the likely increasing surface water concentrations of methylmercury. The high water levels present in 2012 within the Upper Reservoir likely resulted in high levels of methylmercury being released to the overlying surface water (including discharges to the Lower Reservoir) where it was bioaccumulated to high concentrations within forage fish with subsequent biomagnification to larger fish including bluegills, yellow perch, chain pickerel and largemouth bass.

The levels of mercury have significantly increased in zooplankton and forage fish sampled at the Upper and Lower Reservoirs from 2011 through 2014. Zooplankton methylmercury concentrations at the Upper Reservoir in 2013 and 2014 were the highest observed during the biomonitoring while tree swallow egg mercury concentrations at both reservoirs in 2013 were the highest observed during the biomonitoring.

For the Lower Reservoir, a fairly strong positive correlation exists between zooplankton methylmercury concentrations and precipitation received the previous nine months prior to sampling the plankton. No correlation was noted for Upper Reservoir plankton and precipitation data. The greater correlation noted between plankton and precipitation in the Lower Reservoir compared to the Upper Reservoir is not unexpected given that the likely source(s) of mercury to the Lower Reservoir are located within the Upper Reservoir itself (mercury-contaminated sediments) or in the seeps/sediments associated with the SBAC and its meanders. The greater the amount of precipitation received within the watershed of the Lower Reservoir, the greater the increase in the discharge of surface water from the Upper Reservoir (containing methylmercury) to the Lower Reservoir.

A strong correlation exists between for the Upper Reservoir forage fish mercury concentrations and methylmercury concentrations in zooplankton the year prior to collection of the forage fish samples. A less strong correlation also exists for the Upper Reservoir between the forage fish mercury levels and the plankton methylmercury concentrations sampled at the same time as the forage fish. Weak correlations are present with forage fish mercury concentrations noted at the Upper Reservoir and the 4, 6, 9 and 11 month precipitation data. Forage fish mercury levels from the Lower Reservoir were weakly correlated with both plankton and precipitation data. It is unclear what factor(s) may be involved in the differing levels of mercury noted in the forage fish collected from the Lower Reservoir.

Strong correlations are present between average-sized piscivorous fish (chain pickerel and largemouth bass) and forage fish collected from the Upper Reservoir. The strong similarity between increasing and decreasing mercury concentrations within pickerel/bass and forage fish is likely attributable to the fact that forage fish represent the primary prey for pickerel and bass. Bluegills and forage fish from the Upper Reservoir were also correlated but it is believed that is attributable to similar diets (aquatic invertebrates). No significant correlations were noted between average-sized fish from the Lower Reservoir and all of the biota/precipitation factors evaluated. It is unclear what factor(s) may be involved in the differing levels of mercury noted in the average-sized fish collected from the Lower Reservoir.

Tree swallow egg mercury concentrations noted in the Upper Reservoir were correlated with plankton methylmercury levels. Elevated levels of mercury within zooplankton are likely to be correlated with high concentrations of mercury within aquatic insects which comprise important prey for tree swallows. As nesting tree swallows forage on emerging aquatic insects, mercury levels in tree swallow eggs would be expected to increase as the levels in their forage base increases. Mercury concentrations in tree swallow eggs collected from the Lower Reservoir were not strongly correlated with any of the factors evaluated. It is unclear what factor(s) may be involved in the differing levels of mercury noted in the eggs collected from the Lower Reservoir.

High methylmercury and mercury concentrations within biota sampled from the Upper Reservoir and Lower Reservoir have been noted from 2011 through 2014. It is possible that methylmercury production from recently re-inundated sediments of the Upper Reservoir is still occurring by anaerobic bacteria as sediments within shallow water portions of the Upper Reservoir change from aerobic to anoxic conditions. As the concentrations of mercury, sulfides and organic matter within the anaerobic sediment comes into equilibrium then methylmercury production should decrease and biota concentrations may return to levels noted prior to the initial drawdown of the Upper Reservoir in fall 2004. However, in studies involving newly flooded reservoirs in Canada and Europe, elevated mercury levels remained high for up to 30 years following inundation (Bodaly et al., 2007; Porvari, 1998; St. Louis et al., 2004). It is unclear if the Upper Reservoir which was previously flooded for many decades will exhibit the same characteristics regarding mercury accumulation as newly flooded environments following its recent re-inundation.

Median mercury concentrations within bluegills and forage fish are similar and typically near the 24% injury factor reported for fish except in 2012 when median concentrations were at the 50% injury factor. As the median concentrations of both bluegills and forage fish exceed the 24% injury factor over the past six years, it is possible that the population of bluegills within the Upper Reservoir is being affected by the mercury concentrations present in this aquatic habitat. The median concentrations of mercury within chain pickerel and largemouth bass for six of the past seven years are approximately at or exceed the concentration associated with a 50% injury factor. Overall, the median mercury concentrations detected in chain pickerel and largemouth bass suggest that adverse impacts are possible to the populations of these two species. The sharp decline in the number of largemouth bass caught in the 2014 sampling effort may be an indicator that the population of bass within the Upper Reservoir has been adversely affected.

The median concentrations of mercury detected in bluegills are below the 24% injury factor concentration in all 11 years of the biomonitoring study indicating that significant adverse effects to the bluegill population are unlikely. Median forage fish concentrations exceed the 24% injury factor in 2014 only. The median mercury concentrations within yellow perch during all years of the biomonitoring are approximately equal to the 24% injury factor concentration. However, for the past five years, the median yellow perch mercury concentrations exceed this factor (and approach the 50% injury factor in 2014) indicating that this species may be adversely affected by mercury.

Median concentrations of mercury in chain pickerel and largemouth bass exceed the concentration associated with a 24% injury factor while median concentrations of one or both of these species exceed the 50% injury factor concentration in 2011, 2012 and 2014. The median concentrations of mercury detected in large chain pickerel and largemouth bass in 2002 and 2013 (but not 2009) exceed the 50% injury factor. Overall, the detected concentrations of mercury within chain pickerel and largemouth bass indicate that these species may be adversely affected by mercury levels present within the Lower Reservoir.

An evaluation of mercury concentrations in tree swallow eggs indicates that reproductive impacts may be occurring at the Upper and Lower Reservoir (particularly associated with the latest egg samples collected at the Upper Reservoir from 2012 through 2014). Risks to swallows within both reservoirs significantly increased in 2013 and 2014 and is likely attributable to the increased levels present within their prey.

At the Upper Reservoir, the mean forage fish concentrations of mercury exceed the kingfisher Lowest Observable Adverse Effect Level (LOAEL) toxicity reference values (TRV) for all 11 years that forage fish were collected. At the Lower Reservoir, risk to kingfishers from the ingestion of forage fish generally increased from 2005 until 2011, when the mean forage fish mercury concentration was slightly below the kingfisher LOAEL TRV. However, in 2012 through 2014, risks to kingfishers foraging at the Lower Reservoir again increased to levels that exceed the LOAEL TRV. In addition, when the risk associated with foraging on small fish at both reservoirs combined is evaluated, the results suggest even further that reproductive impacts to kingfishers potentially are present.

Risks to osprey associated with ingestion of average-size bluegills, yellow perch, chain pickerel and largemouth bass were evaluated for the Upper and Lower Reservoirs. Overall, osprey may potentially be at risk from foraging on predator fish (chain pickerel and largemouth bass) present within the Upper and Lower Reservoirs, particularly in the recent biomonitoring years of 2011 - 2014. Similar to risks noted for the kingfisher, risks associated with osprey are expected to be in the form of a reduction in their reproduction. Acute adverse effects such as direct mortality of ospreys or kingfishers from ingesting fish containing elevated concentrations of mercury are not anticipated.

Mean mercury concentrations in bluegills, chain pickerel and largemouth bass at the Upper Reservoir and chain pickerel, largemouth bass and yellow perch sampled at the Lower Reservoir exceed the mink LOAEL fish tissue TRV. Exceeding the LOAEL HQ is considered significant for the mink as the LOAEL is based on actual mink neurotoxicity and mortality (Chamberland et al., 1996). Fish tissue concentrations of mercury detected at both the Upper and Lower Reservoir strongly suggest that mercury-related impacts to mink may result from consuming average-sized fish from these reservoirs.

As significantly increasing trends in mercury concentrations have been observed in forage fish from the Upper Reservoir and within average-sized fish within both reservoirs, the risks to piscivorous species including the belted kingfisher, osprey and mink have also steadily increased over the duration of the biomonitoring period.

5.2 Future Biomonitoring Recommendations

The biomonitoring program has been developed to facilitate annual comparisons between mercury and/or methylmercury levels within various biota inhabiting Area U. In this manner, temporal and spatial variability in mercury concentrations within Area U biota can be determined. Area U biota currently or formerly monitored include zooplankton (within the Upper and Lower Atlantic City Reservoirs), aquatic macroinvertebrates (isopods and dragonfly larvae within the SBAC), forage fish (within SBAC, Upper and Lower Atlantic City Reservoirs and tidal portion of Absecon Creek), average-sized fish (representing different foraging guilds within the Upper and Lower Atlantic City Reservoirs), birds (tree swallow eggs at the Upper and Lower Atlantic City Reservoirs) and bats (northern long-eared bat fur).

The biomonitoring of biota within Area U has been conducted annually since 2005 and has provided extremely useful information. This effort is essential in ascertaining the yearly distribution and variability of mercury within the aquatic ecosystems in Area U as well as evaluating the effectiveness of future remediation efforts. It is recommended that the biomonitoring program be continued in 2015 to further develop additional insight into mercury bioaccumulation processes that are occurring within Area U, particularly in light of the recent re-inundation of previously exposed sediments within the Upper Reservoir with the completion of dam repairs in 2011 and the subsequent very high levels of mercury noted in 2012 through 2014 biota samples collected from the Upper and Lower Reservoirs. This sampling would include annual sampling of forage fish, average-sized fish, and tree swallow eggs.

Yearly fall sampling of zooplankton within both reservoirs should also continue. Spring and/or fall sampling of one or two surface water samples within each reservoir for mercury and methylmercury may also provide additional insight into current bioaccumulation factors as well as sources of mercury input given that quarterly surface water samples are currently being collected from the SBAC and analyzed for mercury.

The sampling of northern long-eared bat fur should continue to be analyzed on a yearly basis, particularly given the recent decision by the USFWS to list this species as Threatened.

In summary, 2015 biomonitoring activities should include zooplankton, forage fish, average-size fish and tree swallow eggs at the Upper and Lower Reservoirs while northern long-eared bat fur samples should be collected throughout Area U.

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ATTACHMENT A

Individual Fish Mercury Sampling Data

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2004	Bluegill	207	160	1.30	UR-6
2004	Bluegill	204	180	1.20	UR-7
2004	Bluegill	199	150	1.10	UR-8
2004	Bluegill	216	190	1.40	UR-4
2004	Bluegill	197	140	1.00	UR-6
2004	Bluegill	207	200	1.50	UR-3
2004	Bluegill	167	30	0.48	LR-3
2004	Bluegill	169	60	0.41	LR-3
2004	Bluegill	176	100	0.23	LR-4
2004	Bluegill	163	80	0.76	LR-10
2004	Chain Pickerel	280	300	1.80	UR-6
2004	Chain Pickerel	276	300	1.80	UR-6
2004	Chain Pickerel	375	300	2.10	UR-8
2004	Chain Pickerel	370	250	3.70	UR-8
2004	Chain Pickerel	332	220	1.80	UR-6
2004	Chain Pickerel	310	160	3.00	UR-7
2004	Chain Pickerel	325	150	1.80	LR-5
2004	Chain Pickerel	334	150	1.00	LR-1
2004	Chain Pickerel	360	220	1.00	LR-3
2004	Chain Pickerel	348	205	1.20	LR-3
2004	Largemouth Bass	227	110	1.70	UR-4
2004	Largemouth Bass	203	100	1.80	UR-3
2004	Largemouth Bass	232	130	1.90	UR-4
2004	Largemouth Bass	236	140	1.40	UR-1
2004	Largemouth Bass	261	190	2.30	UR-7
2004	Largemouth Bass	237	150	1.80	UR-4
2004	Largemouth Bass	291	300	1.80	LR-9
2004	Largemouth Bass	295	300	1.40	LR-4
2004	Largemouth Bass	281	280	1.40	LR-4
2004	Yellow Perch	211	70	1.20	LR-6
2004	Yellow Perch	214	100	1.50	LR-7
2004	Yellow Perch	210	80	0.78	LR-6
2004	Yellow Perch	215	80	1.10	LR-4
2005	Bluegill	207	200	1.00	UR-1
2005	Bluegill	210	205	1.10	UR-3
2005	Bluegill	202	180	0.90	UR-6
2005	Bluegill	204	160	1.20	UR-6

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2005	Bluegill	203	185	0.96	UR-1
2005	Bluegill	199	160	1.20	UR-6
2005	Bluegill	171	80	0.63	LR-3
2005	Bluegill	164	70	0.62	LR-5
2005	Bluegill	165	75	0.47	LR-4
2005	Bluegill	175	120	0.29	LR-1
2005	Chain Pickerel	308	160	1.80	UR-1
2005	Chain Pickerel	334	215	1.90	UR-5
2005	Chain Pickerel	309	165	2.20	UR-5
2005	Chain Pickerel	359	270	2.00	UR-1
2005	Chain Pickerel	331	210	2.10	UR-1
2005	Chain Pickerel	318	160	2.00	UR-1
2005	Chain Pickerel	309	120	0.52	LR-4
2005	Chain Pickerel	335	230	1.30	LR-6
2005	Chain Pickerel	344	210	1.40	LR-6
2005	Chain Pickerel	341	200	1.20	LR-4
2005	Largemouth Bass	220	130	1.70	UR-4
2005	Largemouth Bass	240	130	2.10	UR-4
2005	Largemouth Bass	220	115	2.20	UR-4
2005	Largemouth Bass	214	120	1.60	UR-2
2005	Largemouth Bass	260	195	2.20	UR-2
2005	Largemouth Bass	263	200	1.70	UR-6
2005	Largemouth Bass	283	270	1.40	LR-6
2005	Largemouth Bass	289	315	0.90	LR-1
2005	Largemouth Bass	283	350	0.81	LR-1
2005	Largemouth Bass	287	315	0.77	LR-3
2005	Yellow Perch	210	75	0.95	LR-3
2005	Yellow Perch	205	100	0.86	LR-7
2005	Yellow Perch	192	40	1.00	LR-6
2005	Yellow Perch	260	170	1.20	LR-7
2006	Bluegill	208	190	1.00	UR-6
2006	Bluegill	204	180	1.10	UR-1
2006	Bluegill	210	200	1.10	UR-5
2006	Bluegill	212	200	1.30	UR-5
2006	Bluegill	195	155	1.40	UR-1
2006	Bluegill	205	120	0.98	UR-5
2006	Bluegill	161	75	0.37	LR-3

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2006	Bluegill	158	65	0.43	LR-8
2006	Bluegill	157	80	0.30	LR-1
2006	Bluegill	149	65	0.44	LR-5
2006	Chain Pickerel	345	255	1.50	UR-2
2006	Chain Pickerel	405	380	2.00	UR-4
2006	Chain Pickerel	384	335	1.60	UR-6
2006	Chain Pickerel	384	300	1.90	UR-6
2006	Chain Pickerel	335	195	1.20	LR-7
2006	Chain Pickerel	375	280	1.40	LR-1
2006	Chain Pickerel	374	300	1.90	LR-5
2006	Chain Pickerel	355	250	0.64	LR-3
2006	Largemouth Bass	271	220	1.90	UR-1
2006	Largemouth Bass	230	150	1.40	UR-6
2006	Largemouth Bass	218	130	1.70	UR-6
2006	Largemouth Bass	224	135	1.20	UR-1
2006	Largemouth Bass	252	225	2.30	UR-2
2006	Largemouth Bass	269	255	1.70	UR-4
2006	Largemouth Bass	291	295	1.60	LR-1
2006	Largemouth Bass	282	250	1.50	LR-2
2006	Largemouth Bass	305	310	1.50	LR-5
2006	Largemouth Bass	262	200	1.60	LR-3
2006	Yellow Perch	210	105	0.94	LR-8
2006	Yellow Perch	224	115	1.00	LR-7
2006	Yellow Perch	225	115	0.99	LR-1
2006	Yellow Perch	212	95	1.10	LR-5
2007	Bluegill	207	220	1.20	UR-2
2007	Bluegill	205	190	1.10	UR-1
2007	Bluegill	200	160	1.00	UR-6
2007	Bluegill	202	180	1.00	UR-6
2007	Bluegill	205	185	0.83	UR-4
2007	Bluegill	202	195	1.20	UR-6
2007	Bluegill	166	100	0.56	LR-9
2007	Bluegill	160	100	1.20	LR-9
2007	Bluegill	170	115	0.15	LR-3
2007	Bluegill	169	85	0.54	LR-3
2007	Chain Pickerel	341	245	2.20	UR-7
2007	Chain Pickerel	354	290	1.90	UR-7

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2007	Chain Pickerel	350	265	1.80	UR-7
2007	Chain Pickerel	352	270	1.90	UR-6
2007	Chain Pickerel	358	300	2.00	UR-6
2007	Chain Pickerel	342	270	1.90	UR-4
2007	Chain Pickerel	325	160	1.10	LR-4
2007	Chain Pickerel	325	155	0.76	LR-3
2007	Chain Pickerel	331	170	0.86	LR-3
2007	Chain Pickerel	340	180	1.10	LR-3
2007	Largemouth Bass	247	185	2.20	UR-5
2007	Largemouth Bass	242	160	1.90	UR-2
2007	Largemouth Bass	253	165	2.60	UR-2
2007	Largemouth Bass	240	160	3.20	UR-2
2007	Largemouth Bass	228	145	2.20	UR-1
2007	Largemouth Bass	261	235	2.10	UR-2
2007	Largemouth Bass	285	290	1.60	LR-9
2007	Largemouth Bass	285	325	1.30	LR-3
2007	Largemouth Bass	275	265	1.10	LR-3
2007	Largemouth Bass	295	305	0.98	LR-2
2007	Yellow Perch	202	70	0.69	LR-1
2007	Yellow Perch	238	145	1.50	LR-4
2007	Yellow Perch	165	35	0.68	LR-3
2007	Yellow Perch	164	35	0.40	LR-4
2008	Bluegill	210	230	0.788	UR-1
2008	Bluegill	199	185	1.14	UR-4
2008	Bluegill	205	196	1.64	UR-4
2008	Bluegill	203	175	1.29	UR-1
2008	Bluegill	198	178	1.32	UR-1
2008	Bluegill	202	196	0.985	UR-2
2008	Bluegill	170	89	0.616	LR-6
2008	Bluegill	166	92	0.533	LR-6
2008	Bluegill	164	82	0.572	LR-3
2008	Bluegill	165	85	0.674	LR-1
2008	Chain Pickerel	380	285	3.78	UR-3
2008	Chain Pickerel	382	340	3.35	UR-5
2008	Chain Pickerel	380	280	2.88	UR-5
2008	Chain Pickerel	292	124	2.86	UR-1
2008	Chain Pickerel	351	249	2.05	LR-9

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2008	Chain Pickerel	365	252	1.84	LR-6
2008	Chain Pickerel	360	256	1.54	LR-6
2008	Chain Pickerel	372	278	1.42	LR-2
2008	Largemouth Bass	271	265	3.02	UR-6
2008	Largemouth Bass	270	285	3.52	UR-2
2008	Largemouth Bass	242	208	2.72	UR-1
2008	Largemouth Bass	255	246	2.28	UR-1
2008	Largemouth Bass	271	270	2.74	UR-4
2008	Largemouth Bass	274	253	3.18	UR-1
2008	Largemouth Bass	290	315	2.86	LR-8
2008	Largemouth Bass	292	330	1.20	LR-2
2008	Largemouth Bass	296	322	1.42	LR-2
2008	Largemouth Bass	276	260	1.36	LR-2
2008	Yellow Perch	225	128	1.08	LR-7
2008	Yellow Perch	215	115	0.952	LR-7
2008	Yellow Perch	225	120	1.02	LR-6
2008	Yellow Perch	211	93	0.759	LR-6
2009	Bluegill	207	177	1.40	UR-4
2009	Bluegill	212	178	1.83	UR-5
2009	Bluegill	196	154	0.631	UR-6
2009	Bluegill	212	198	1.07	UR-7
2009	Bluegill	212	206	1.14	UR-1
2009	Bluegill	205	170	1.18	UR-1
2009	Bluegill	155	69	0.821	LR-2
2009	Bluegill	165	95	0.34	LR-3
2009	Bluegill	167	82	0.489	LR-4
2009	Bluegill	162	78	0.54	LR-8
2009	Chain Pickerel	353	255	1.70	UR-4
2009	Chain Pickerel	331	168	1.80	UR-4
2009	Chain Pickerel	462	490	4.36	UR-5
2009	Chain Pickerel	327	178	1.85	UR-5
2009	Chain Pickerel	345	218	1.81	UR-6
2009	Chain Pickerel	508	600	4.77	UR-7
2009	Chain Pickerel	335	194	2.25	UR-7
2009	Chain Pickerel	345	215	2.10	UR-3
2009	Chain Pickerel	522	825	3.66	UR-6
2009	Chain Pickerel	357	220	1.16	LR-2

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2009	Chain Pickerel	335	210	1.48	LR-7
2009	Chain Pickerel	472	440	1.46	LR-6
2009	Chain Pickerel	365	263	1.08	LR-3
2009	Chain Pickerel	339	201	0.773	LR-2
2009	Chain Pickerel	492	575	2.10	LR-6
2009	Largemouth Bass	474	1310	8.00	UR-6
2009	Largemouth Bass	251	191	3.24	UR-6
2009	Largemouth Bass	253	210	1.99	UR-7
2009	Largemouth Bass	227	125	2.11	UR-3
2009	Largemouth Bass	248	188	1.92	UR-3
2009	Largemouth Bass	232	148	2.57	UR-4
2009	Largemouth Bass	235	144	1.71	UR-2
2009	Largemouth Bass	399	655	4.62	UR-5
2009	Largemouth Bass	412	825	3.89	UR-1
2009	Largemouth Bass	498	1590	5.94	UR-1
2009	Largemouth Bass	426	985	4.11	UR-4
2009	Largemouth Bass	421	795	2.52	LR-4
2009	Largemouth Bass	305	320	1.19	LR-7
2009	Largemouth Bass	415	810	3.36	LR-7
2009	Largemouth Bass	300	320	1.44	LR-6
2009	Largemouth Bass	417	840	1.74	LR-2
2009	Largemouth Bass	298	340	1.15	LR-3
2009	Largemouth Bass	427	990	2.38	LR-3
2009	Largemouth Bass	284	260	1.23	LR-4
2009	Yellow Perch	225	113	0.267	LR-3
2009	Yellow Perch	202	88	0.482	LR-3
2009	Yellow Perch	222	120	1.12	LR-8
2009	Yellow Perch	215	100	1.00	LR-7
2010	Bluegill	202	167	1.22	UR-4
2010	Bluegill	210	191	1.46	UR-4
2010	Bluegill	200	184	1.42	UR-2
2010	Bluegill	205	180	1.72	UR-4
2010	Bluegill	214	183	1.96	UR-5
2010	Bluegill	203	175	1.44	UR-2
2010	Bluegill	150	53	0.481	LR-8
2010	Bluegill	160	67	0.675	LR-7
2010	Bluegill	150	55	0.673	LR-7

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2010	Bluegill	156	65	0.713	LR-3
2010	Bluegill	170	88	0.561	LR-3
2010	Chain Pickerel	358	302	2.65	UR-2
2010	Chain Pickerel	350	228	3.29	UR-4
2010	Chain Pickerel	321	188	1.40	UR-4
2010	Chain Pickerel	313	153	2.86	UR-4
2010	Chain Pickerel	317	169	3.10	UR-5
2010	Chain Pickerel	312	178	2.31	UR-2
2010	Chain Pickerel	335	173	1.61	LR-8
2010	Chain Pickerel	370	300	1.66	LR-7
2010	Chain Pickerel	348	201	1.91	LR-7
2010	Chain Pickerel	371	259	1.74	LR-3
2010	Chain Pickerel	364	241	1.64	LR-4
2010	Largemouth Bass	269	260	3.10	UR-4
2010	Largemouth Bass	266	238	1.93	UR-4
2010	Largemouth Bass	274	275	2.76	UR-2
2010	Largemouth Bass	277	286	3.37	UR-4
2010	Largemouth Bass	251	220	3.06	UR-5
2010	Largemouth Bass	255	208	2.94	UR-2
2010	Largemouth Bass	289	283	1.50	LR-9
2010	Largemouth Bass	290	279	1.56	LR-1
2010	Largemouth Bass	298	299	1.45	LR-1
2010	Largemouth Bass	280	249	1.39	LR-3
2010	Largemouth Bass	271	211	1.42	LR-2
2010	Yellow Perch	215	115	1.36	LR-9
2010	Yellow Perch	204	83	1.41	LR-8
2010	Yellow Perch	210	95	1.15	LR-8
2010	Yellow Perch	223	113	1.56	LR-7
2010	Yellow Perch	223	105	1.12	LR-4
2011	Bluegill	202	155	1.28	UR-3
2011	Bluegill	202	160	1.48	UR-3
2011	Bluegill	200	160	0.934	UR-3
2011	Bluegill	209	180	1.29	UR-7
2011	Bluegill	206	170	1.39	UR-6
2011	Bluegill	212	185	1.62	UR-6
2011	Bluegill	160	70	0.609	LR-6
2011	Bluegill	155	55	0.821	LR-6

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2011	Bluegill	162	95	0.35	LR-3
2011	Bluegill	164	70	0.683	LR-3
2011	Bluegill	163	70	0.541	LR-2
2011	Chain Pickerel	346	230	2.86	UR-3
2011	Chain Pickerel	360	260	4.03	UR-7
2011	Chain Pickerel	344	240	2.86	UR-6
2011	Chain Pickerel	308	150	2.49	UR-3
2011	Chain Pickerel	314	150	2.73	UR-4
2011	Chain Pickerel	365	240	3.44	UR-4
2011	Chain Pickerel	370	260	2.99	LR-8
2011	Chain Pickerel	365	220	3.57	LR-8
2011	Chain Pickerel	355	220	3.33	LR-7
2011	Chain Pickerel	321	160	2.33	LR-6
2011	Chain Pickerel	355	225	1.30	LR-1
2011	Largemouth Bass	262	245	3.56	UR-3
2011	Largemouth Bass	251	200	3.61	UR-6
2011	Largemouth Bass	276	270	4.07	UR-6
2011	Largemouth Bass	267	280	3.41	UR-4
2011	Largemouth Bass	262	240	3.90	UR-7
2011	Largemouth Bass	276	275	2.96	UR-4
2011	Largemouth Bass	305	370	1.77	LR-3
2011	Largemouth Bass	292	290	1.85	LR-6
2011	Largemouth Bass	299	320	2.06	LR-5
2011	Largemouth Bass	290	295	1.84	LR-5
2011	Largemouth Bass	288	265	2.16	LR-3
2011	Yellow Perch	212	110	2.57	LR-8
2011	Yellow Perch	214	115	1.40	LR-8
2011	Yellow Perch	215	105	1.29	LR-7
2011	Yellow Perch	215	100	1.58	LR-6
2011	Yellow Perch	217	120	0.88	LR-1
2012	Bluegill	197	160	3.16	UR-5
2012	Bluegill	210	175	3.84	UR-7
2012	Bluegill	196	150	3.33	UR-8
2012	Bluegill	214	190	3.05	UR-6
2012	Bluegill	204	175	2.63	UR-1
2012	Bluegill	207	180	0.969	UR-6
2012	Bluegill	161	65	1.09	LR-9

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2012	Bluegill	154	60	0.694	LR-6
2012	Bluegill	162	70	0.754	LR-6
2012	Bluegill	167	80	0.871	LR-5
2012	Bluegill	162	70	1.13	LR-3
2012	Chain Pickerel	351	220	7.76	UR-5
2012	Chain Pickerel	354	200	6.28	UR-6
2012	Chain Pickerel	331	180	7.02	UR-6
2012	Chain Pickerel	354	210	7.38	UR-7
2012	Chain Pickerel	324	180	6.80	UR-9
2012	Chain Pickerel	348	190	6.51	UR-2
2012	Chain Pickerel	369	260	4.74	LR-7/8
2012	Chain Pickerel	362	230	3.18	LR-6
2012	Chain Pickerel	360	210	3.65	LR-6
2012	Chain Pickerel	364	220	3.14	LR-5
2012	Chain Pickerel	368	230	3.90	LR-4
2012	Largemouth Bass	242	170	4.82	UR-5
2012	Largemouth Bass	230	140	7.40	UR-6
2012	Largemouth Bass	274	230	7.46	UR-6
2012	Largemouth Bass	254	180	8.79	UR-6
2012	Largemouth Bass	254	160	7.63	UR-3
2012	Largemouth Bass	258	210	10.8	UR-2
2012	Largemouth Bass	300	300	3.11	LR-3/6
2012	Largemouth Bass	299	280	2.75	LR-4/6
2012	Largemouth Bass	274	255	3.25	LR-3/6
2012	Largemouth Bass	278	250	3.10	LR-3/6
2012	Yellow Perch	214	120	2.30	LR-9/10
2012	Yellow Perch	221	110	2.04	LR-9/10
2012	Yellow Perch	218	120	3.07	LR-7/8
2012	Yellow Perch	221	120	3.08	LR-4
2012	Yellow Perch	215	100	2.56	LR-3
2013	Bluegill	197	160	1.70	UR-7
2013	Bluegill	198	162	2.11	UR-7
2013	Bluegill	210	178	0.995	UR-6
2013	Bluegill	203	168	1.24	UR-6
2013	Bluegill	205	178	1.25	UR-2
2013	Bluegill	208	202	2.34	UR-3
2013	Bluegill	168	92	0.402	LR-3

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2013	Bluegill	154	62	0.465	LR-3
2013	Bluegill	161	70	0.555	LR-7
2013	Bluegill	167	88	0.573	LR-7
2013	Bluegill	158	68	0.46	LR-2
2013	Chain Pickerel	321	173	5.91	UR-7
2013	Chain Pickerel	327	178	4.95	UR-6
2013	Chain Pickerel	327	185	5.10	UR-6
2013	Chain Pickerel	312	160	5.00	UR-4
2013	Chain Pickerel	325	176	4.77	UR-4
2013	Chain Pickerel	347	240	4.50	UR-5
2013	Chain Pickerel	461	520	6.77	UR-7
2013	Chain Pickerel	475	585	5.32	UR-7
2013	Chain Pickerel	506	730	1.41	UR-7
2013	Chain Pickerel	464	495	6.30	UR-7
2013	Chain Pickerel	467	470	7.21	UR-5
2013	Chain Pickerel	345	195	1.73	LR-7
2013	Chain Pickerel	367	250	2.35	LR-7
2013	Chain Pickerel	365	225	2.05	LR-4
2013	Chain Pickerel	348	200	1.58	LR-4
2013	Chain Pickerel	350	223	1.67	LR-4
2013	Chain Pickerel	480	575	2.26	LR-7
2013	Chain Pickerel	474	450	4.20	LR-1
2013	Chain Pickerel	628	1440	9.24	LR-9
2013	Chain Pickerel	456	405	4.11	LR-9
2013	Chain Pickerel	506	640	4.03	LR-9
2013	Largemouth Bass	271	260	5.61	UR-7
2013	Largemouth Bass	279	264	5.76	UR-7
2013	Largemouth Bass	262	230	5.69	UR-7
2013	Largemouth Bass	255	210	6.02	UR-6
2013	Largemouth Bass	255	205	5.13	UR-4
2013	Largemouth Bass	254	195	4.32	UR-5
2013	Largemouth Bass	425	910	4.02	UR-6
2013	Largemouth Bass	438	1110	8.12	UR-6
2013	Largemouth Bass	437	1100	5.50	UR-5
2013	Largemouth Bass	411	860	5.79	UR-4
2013	Largemouth Bass	380	820	5.72	UR-6
2013	Largemouth Bass	296	330	1.53	LR-3

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2013	Largemouth Bass	280	300	2.25	LR-4
2013	Largemouth Bass	285	295	2.01	LR-7
2013	Largemouth Bass	292	285	1.81	LR-1
2013	Largemouth Bass	291	305	1.76	LR-1
2013	Largemouth Bass	485	1670	4.36	LR-2
2013	Largemouth Bass	416	855	3.78	LR-6
2013	Largemouth Bass	457	1300	4.62	LR-7
2013	Largemouth Bass	412	800	2.89	LR-2
2013	Largemouth Bass	422	940	3.56	LR-2
2013	Yellow Perch	221	104	0.666	LR-3
2013	Yellow Perch	217	100	1.86	LR-7
2013	Yellow Perch	223	102	1.56	LR-7
2013	Yellow Perch	224	113	1.69	LR-4
2013	Yellow Perch	205	86	0.793	LR-7
2014	Bluegill	200	175	1.10	UR-6
2014	Bluegill	204	200	1.93	UR-6
2014	Bluegill	211	230	2.62	UR-7/8
2014	Bluegill	212	205	1.40	UR-6
2014	Bluegill	210	175	2.21	UR-2
2014	Bluegill	210	220	2.20	UR-4
2014	Bluegill	148	80	0.512	LR-3
2014	Bluegill	152	65	0.615	LR-6
2014	Bluegill	152	88	0.804	LR-8
2014	Bluegill	170	82	0.820	LR-9
2014	Bluegill	152	74	0.680	LR-5/6
2014	Chain Pickerel	350	300	4.87	UR-5
2014	Chain Pickerel	342	270	4.64	UR-5
2014	Chain Pickerel	331	195	4.86	UR-6
2014	Chain Pickerel	355	250	5.65	UR-7/8
2014	Chain Pickerel	338	225	6.24	UR-7/8
2014	Chain Pickerel	357	270	4.73	UR-4
2014	Chain Pickerel	312	160	1.37	LR-3
2014	Chain Pickerel	340	210	2.48	LR-8
2014	Chain Pickerel	370	255	3.43	LR-7
2014	Chain Pickerel	368	255	3.55	LR-5/6
2014	Chain Pickerel	374	245	3.85	LR-4
2014	Largemouth Bass	280	300	6.23	UR-6

Table A-1
Upper Reservoir and Lower Reservoir Fish Sample Data
2004 - 2014

Year	Species	Length (mm)	Weight (g)	Total Hg	Location
2014	Largemouth Bass	274	270	4.66	UR-3
2014	Largemouth Bass	285	320	6.23	UR-4
2014	Largemouth Bass	259	220	3.58	UR-4
2014	Largemouth Bass	281	240	5.55	UR-5
2014	Largemouth Bass	246	220	4.72	UR-5
2014	Largemouth Bass	286	295	1.68	LR-3
2014	Largemouth Bass	277	265	2.81	LR-6
2014	Largemouth Bass	276	206	3.17	LR-5/6
2014	Yellow Perch	220	125	0.882	LR-3
2014	Yellow Perch	222	160	2.79	LR-8
2014	Yellow Perch	218	140	2.41	LR-5/6
2014	Yellow Perch	231	154	1.95	LR-7
2014	Yellow Perch	196	112	2.36	LR-7